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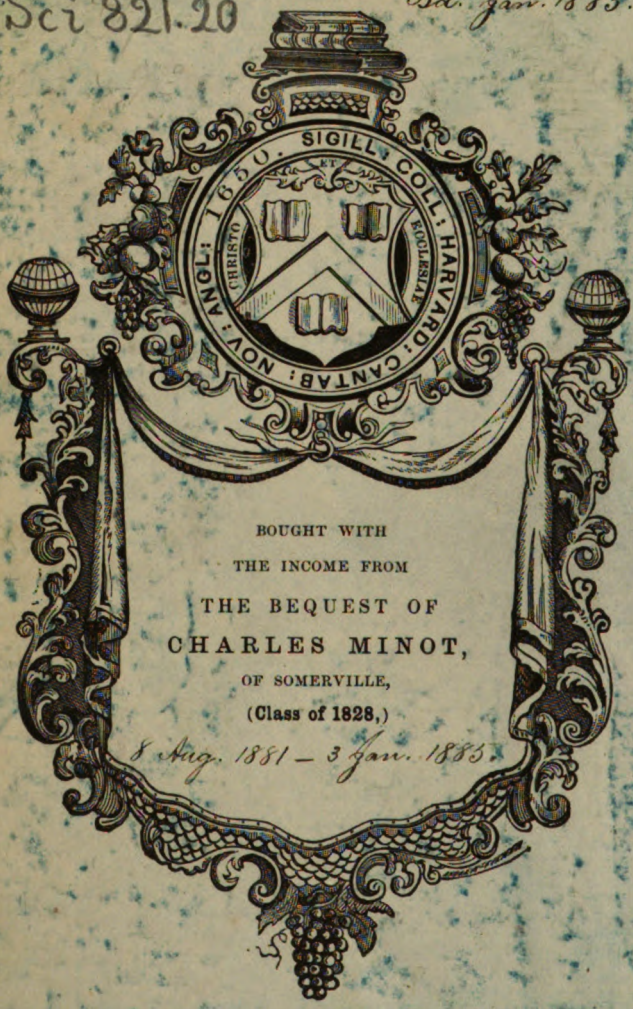

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BIBLIOGRAPHY, GUIDE AND INDEX

TO

CLIMATE.

BY

ALEXANDER RAMSAY,

F.G.S., F.R.G.S., F.R. MET. SOC., F. SCOT. M.S., ETC.

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THE

SCIENTIFIC ROLL

AND

Magazine of Systematized Notes.

CONDUCTED BY

ALEXANDER RAMSAY.

CLIMATE.

VOL. I.

Let there be truth and let there be order: for truth and order regulate all things in the realm of nature, and the laws of nature are the visible expression of the active thoughts of God.

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1881. Aug. 8,
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THE SCIENTIFIC ROLL

AND

Magazine of Systematized Notes.

INTRODUCTION.

1. CAPTAIN CUTTLE'S recommendation to make a note of a fact, when once it has been found, has long since passed into a familiar and well-approved-of by-word. The full advantage of the operation, however, is not obtained until the note made has been put where it can be easily referred to again whenever wanted.

2. Scientific literature has long since become an immense storehouse of facts, the contents of which are so arranged that in many cases it is very difficult indeed to find the individual statement wished for. Every year the difficulty increases, and efforts are made from time to time to meet it by means of records, annuals, classified catalogues, digests and indexes. These works are unquestionably useful, and all honour is due to those who have conceived and executed them; but the principles upon which they are based do not seem calculated to supply the great desideratum, viz. a simple, uniformly arranged key to, and summary of, science.

3. A plan for effecting this is here proposed. It is to thoroughly search each paper or volume and arrange its contents under specified headings classified according to a definite order. In this way the information supplied by that particular paper or volume is placed within easy reach of everyone. By extending this process to other papers and volumes, fresh facts are obtained and classified. The larger the area of literature the process is applied to, the more useful becomes the collection of systematised notes. When a large number of books have been thus treated, the analyser finds that owing to repetition each additional work which is examined contains comparatively little that has not already been entered in the notes. The systematisation of notes, hence, necessarily results in the most compendious condensation and concentration possible of all that is wanted in scientific literature, so arranged that, generally, any particular fact would be far more accessible in its new position than where it was originally placed.

4. The 'SCIENTIFIC ROLL' will endeavour to develope this idea. It would be impossible to complete the task without a great deal of organised co-operation. Still it is hoped that the beginning here offered will be found sufficiently useful to lead to the plan being carried out on a larger and more efficient scale. When it is considered that there are upwards of six thousand distinct scientific serials it will be manifest that the 'SCIENTIFIC ROLL' does not claim to make any approach to completeness, except in so far as relates to the books or articles which are marked as having been read.

5. Notes thus collected may have a somewhat disconnected appearance so far as the want of fluency of language is concerned, but the contiguous statements usually have such a close connection with each other that the flow of ideas is unexpectedly even, so that not only are lines of thought suggested, but facilities are offered for following them out, which books as a rule do not afford.

6. An opportunity will be taken at a later period for giving a full explanation of the system developed in the following pages. Here, however, it may be mentioned that although passages are often taken verbatim, quotation marks are not given. In all cases the endeavour is to give the substantial meaning as briefly as possible; so that when it happens that to follow the actual words of the author would be useless verbosity, the passage is summarised. No attempt is made at altering the sense, or correcting mistakes of fact or spelling, or modifying anything which bears upon the subject of the heading Everything unconnected with the subject under consideration for the time is omitted. Hence it will be clear that for purposes of quotation the original work must be consulted. Correction of errors, comments and explanatory remarks by the Conductor or his coadjutors, will invariably be placed in footnotes.

7. Considerable help has been afforded by the Royal Society's Catalogue of Scientific Papers, *Nature*, and many other useful repertories. Full acknowledgments of this kind will be made at the close of each section of the work. The matter is mentioned here because in the case of titles, and such like data, it would be inconvenient and unusual to cite the work whose authority is relied on for them. Many of the titles have been independently verified.

8. Explanations of the contractions used will be given in due course. One or two, however, require elucidation now. Every item, whether it be a paper, or a volume, or a series which has been examined and the facts afforded by it placed in the notes, is marked *ra* if the article only has been read; *rv* if the volume has been analysed; and *rs* if the series has been searched; but when such item has been read too late for the insertion of the facts in their proper place in a previously published part of the magazine, it will be marked *rp*.

9. Authors desirous of securing a notice of their publications will be conferring a favour by sending a copy of them to the Conductor, which will be returned to them, if desired, as soon as they have been analysed. Publishers and authors are respectfully asked to send early notice of all publications bearing upon meteorology, as by so doing they will enable the Conductor to incorporate the most recently published works.

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ESSAY I.

ON THE DIURNAL PERIODICITY.

1. THE local weather changes are often and in many places so frequent and so abrupt that many nations have regarded the observed succession of cold and heat; of rain, snow, hail, storms of wind, and of fine weather; of electrical disturbance and of electrical calm, as almost matters of chance. Indeed the changes of the weather are commonly referred to as typical of fickleness. In other cases, where a number of laws have worked together for the production of a single event, individuals are prone to say that chance, not law, has brought it about. The knocking-down of a person by a vehicle in the crowded streets of a city; the so-called trifling events which accompany the perpetration of a crime or the achievement of a national blessing; the arrangement of the stones on a pebble beach or of the stars in the heavens; the collocation of two or three individual particles in this or that particular muscle or other organised structure; the event of two black balls being drawn from a heap of a 1000 balls, 500 of which are black, and 500 white—all these, and countless other examples which the reader can easily supply, are said to be (to a greater or less degree) dependent upon chance. But when each individual case is followed out in detail and the cases of the like kind are grouped together, then the larger the number of examples forming each group the more evidently are the laws which governed its occurrence made manifest. Thus with reference to the persons who are knocked down by vehicles in the streets of London, the active concomitants are so regular that it is possible to say beforehand, with a near approach to accuracy, how many persons will be run over in the ensuing week, and what proportion the fatal injuries will bear to those which are not fatal. The degree of accuracy of the prediction will depend upon the fulness of the knowledge possessed of the concurrent circumstances which produce such accidents. And so it is with the other illustrative instances mentioned. The arrangement of the pebbles upon a beach is undoubtedly the result of the action of many definite laws, and so also, scientific faith compels us to believe, are the mazy arrangements of the starry hosts of heaven and of the countless molecules of matter.

2. As then the rational grouping of like circumstantialities enables the statistician to discern law where chance is ordinarily supposed to prevail, so the methodical grouping of facts will allow of the deduction of conclusions which would not have been revealed by the scattered facts. Scientific faith constrains us to admit that law, not chance, reigns over the succession of the least, as well as of the most, striking of the weather phenomena. In proportion as knowledge increases so will faith change into a firmer and firmer conviction that law prevails in these phenomena; and doubtless with perfect knowledge there would be absolute conviction that there is no such thing as chance. Then, indeed, it would be felt that only two positions can be consistently maintained—the one is that everything is a matter of chance, the other that everything is a matter of law; or, in other words, that the universe is under the rule of nothing (which is tantamount to saying it is under no rule at all), or the rule of God. There is no middle position, so that when anything is said to happen by chance, the meaning must be understood to be that it happens according to certain laws, but owing to ignorance of those laws, the how and the why such a thing has happened is beyond the present condition of our understanding.

3. Of late years weather knowledge has made such important advances, that the perusal of a few pages will probably leave an impression on the mind of the reader that there are weather laws, and that meteorological science will become as definite as many of the more advanced sciences.

4. In the present essay the purpose is simply to allude to some facts which indicate the existence of a diurnal periodicity, that is, of a complete succession of climatic events which runs its course within a period of twenty-four hours. The variations which this periodicity may present according to place, and the causes which actually and apparently bring about these variations, will be left for further consideration.

5. The sun is, or appears to be, the great factor in climate; and the relative positions and movements of the earth and sun seem to be most intimately connected with the most prominent climatic periodicities. But there are also periodicities dependent upon other causes, which causes probably are the movements and positions of the moon and planets relatively to each other as well as to the earth, the sun and space, and the changes which are slowly worked out from age to age in the physical geography of the earth itself. But further allusion to these is unnecessary, as the movement of the earth with respect to the sun is, to all appearance, the chief, if not the only, operating cause of the diurnal periodicity.

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6. In consequence of the earth's rotation on its axis the sun appears on the eastern horizon in the lower latitudes, gradually ascends to its highest point in the heavens, then descends to its setting on the western horizon, and remains invisible for a time until it has completed its circuit by reappearing on the eastern horizon. This circuit is effected in twenty-four hours. On and near the equator the days and nights are of equal length all the year round, but as we advance towards the poles the apparent motion of the sun in the sky declines from the vertical plane so that the relative lengths of the day and night fluctuate about the two poles of equality at the spring and autumn equinoxes; the days wax longer from the spring equinox till midsummer, and then wane to the autumn equinox. Then the nights become longer than the days, increasing in length till midwinter; after which they shorten again till the spring equinox. The degree of maximum inequality between daylight and darkness increases as we proceed pole-wards. Beyond the polar circles the duration of the presence or absence of the sun extends over more than twenty-four hours, so that the diurnal period vanishes for a portion of the year. The proportion of the year during which this diurnal movement is non-apparent increases until at and near the poles the apparent solar motion has become horizontal, and the periods of sun-presence and sun-absence are six months in length. In the north hemisphere the diurnal movement is from the left to the right of the observer, while in the south hemisphere the direction is from right to left. Thus although the earth rotates on its axis once in twenty-four hours, the oblique position of that axis, relatively to the position of the sun's axis in space, causes the length of the longest day to increase from twelve hours to six months during one half of the year, and to decrease from twelve hours to zero during the other half. The two hemispheres stand in opposite relations to each other as regards daylight, so that if we select two antipodal places the mean time during which the sun is above the horizon is twelve hours on every day in the year. So again, if we take the mean duration of sun-presence on two days six months apart, it will be found to be twelve hours all the year round.

7. In the preceding paragraph attention has been restricted to the supra-horizontal presence of the sun, but the remarks are so manifestly applicable to light that no observations with instruments are required to convince us that light, as a climatal element, has a periodicity of the same kind; and that the occasional occurrence of dark days in consequence of fogs, showers of volcanic ashes, flights of insects, and other circumstances, does not obscure the evidence.

8. As light and heat are close companions it might be presumed that temperature is subject to similar alternations; but in this case instrumental observations have been made in abundance, and the mind feels the need of other evidence than what is afforded by general scrutiny. The theoretical alternations in the intensity of light may be inferred from the movements of the sun, but practically the actual periodicity differs somewhat from the theoretical owing to the refractive power of the atmosphere and to various local circumstances. The theoretical annual mean would occur at the equinoxes and would be represented by a curve with arms of equal gradient and with six hours above and six hours below the mean. The graphic representation, then, of a semi-diurnal periodicity of twelve hours consists of a single hump with slopes of equal gradient, as in Fig. 1. As the duration of light each day increases, the hump will broaden and its height lessen in proportion to the lessened maximum intensity of the light, until with a diurnal periodicity of almost twenty-four hours the curve would be represented graphically by a broad hump with gradients less than those shown on the equinoxial curve; while in this flatter curve about twelve hours would be above, and twelve below, the mean, as shown in Fig. 2. In this case the means would be at 6 A.M. and 6 P.M. If the increment and decrement were equal for equal portions of time, the lines would be straight; but as the changes are modified in rate by the thickness of air through which the rays pass, the lines assume a curved form.

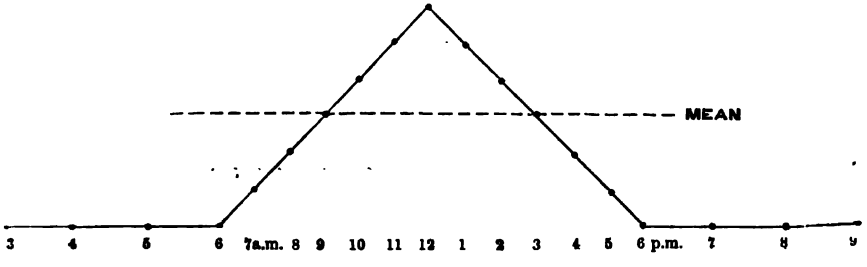

Fig. 1. Theoretical semi-diurnal line.

9. The heat which is supplied by the sun during the day is absorbed by the ground and by the air resting upon it, and is retained by them after the sun has set. There is usually a loss of a portion of this absorbed heat during the night, but in most instances such loss is gradual, so that the accession of heat during

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the day has a greater and more prolonged influence on the nocturnal temperature than the daylight has upon the succeeding period of darkness. Hence the increase and decrease of heat normally extends over the whole twenty-four hours, thus giving rise to a diurnal periodicity. In the construction of diurnal curves it is important to bear in mind that the observations should be such as have been taken at times equal-distanced apart over the whole

Fig. 2. Theoretical diurnal line.

twenty-four hours, and that those times should embrace the epochs of maximum and minimum range. This matter is not of material importance when the object is simply to trace the existence of a diurnal periodicity; but it is essential when the rate of increase and decrease at different localities has to be determined. The point is mentioned here because it has been desirable to utilise observations which suffice for drawing a portion of the diurnal curve in the

tion as to the hours; but as he records the highest and lowest temperatures observed, these help to supply the deficiency in Erskine's figures. The mean of the maximum temperatures is 77° and of the minimum not above 40°. In a subsequent journey through the Limpopo basin, where his former explorations were, Erskine notices that from March 6, the mornings became so cold that the blankets which had been discarded since September were again brought into use. From these scattered materials we are able to infer that the mean night minimum temperature in July in certain parts of the Limpopo basin is not above 40°. Assuming this to be so, and that the moment of minimum cold is shortly before sunrise, the following diurnal curve may be drawn. It is not to be imagined that such a curve is more than a rough approximation to the truth; but these particulars are given to show how scattered isolated

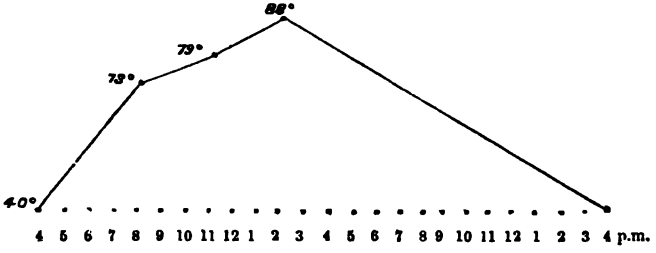

Fig. 3. Hypothetical diurnal curve for July 1878, in the Limpopo river basin.

formation of a complete curve. For instance, Erskine made some observations in July 1868, on the line of the southern tropic in Africa which gave a mean of 73° Fahr. at 9 A.M.; of 79° at noon; and of 88° at 3 P.M. These figures taken by themselves are of little or no value for the present purpose. They indicate a rise from 9 A.M. to 3 P.M. without giving any clue to the times or degrees of the maximum and minimum temperatures. From 9 A.M. to noon the rate of increase is 2° per hour, and from noon to 3 P.M. it is 3°. So far as it goes the evidence would induce us to infer there was a continuous rise up to 3 P.M., and possibly beyond that hour. Incidental mention is made that the temperature of the water is 64°; but the hour of observation is not stated, and a guess has to be hazarded that the water is river water. The minimum, then, would presumably be below 64°. In July 1869, Baines collected some thermometrical data in about the same district, the value of which is diminished owing to want of informa-

notes may have their value enhanced by being placed side by side. The reason why these special figures were taken is because wishing to show proof of the existence of a diurnal periodicity of temperature on the line of the southern tropic of Africa, no better evidence was readily to be found, and these had been collected and systematised. All were found in less than half an hour. Facts, however, are not wanting which will suffice to show that there is unquestionably a diurnal periodicity of temperature in the inter-tropical region of Africa. Watson made observations at Rigaf in December 1874. This locality is in 4° 44′ 32″ N. lat. The mean temperature at 9 A.M. was 82·8°; at 3 P.M. 94°; and at 6 P.M. 82°; the mean maximum in the day was 95°, and the mean minimum at night 69·5°. The maximum was clearly not at 3 P.M.; but judging from analogy and the probabilities of the case it was before rather than after that hour. The increase and decrease of temperature was markedly regular. The range during the

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twenty-four hours varied from 30° to 39°, but at the specified hours it never exceeded 9°. According to Skertchley the average daily temperature in Wassaw, a territory on the Gold Coast which lies between 5° and 6° N. lat., is 75° Fahr., and that of the night 65°. On the Victoria river in Australia, at 15° 30′ S. lat., Wilson found that the minimum temperature occurred about an hour before sunrise; and that the records for nine months gave an average of 72·8° at 6 A.M.; 92·3° at 1 P.M.; and 85·5° at 6 P.M. On the lower Amazon, as at Para, which lies close to the equator, the temperature is remarkably equable, the mean daily temperature according to Orton's observations being 80·2°. The maximum is reached at 2 P.M. and the nights are invariably cool. At Quito, where Orton stayed for a time and registered the thermometric readings, the temperature is very equable. Like Para it is situated close to the equator, but the heat is much moderated owing to its great elevation above the sea. The range in the twenty-four hours is about 10°; the coldest hour is at 6 A.M., and the warmest between 2 and 3 P.M. At Paca-yacu, in Ecuador, Spruce observed the minimum temperature to occur at 6.30 A.M., when it was generally 68°; the maximum was reached at from 2 to 3 P.M., when the temperature usually rose to 81°. At Trevandrum, in S. India, between 8° and 9° N. lat., the mean annual daily temperature rises from a minimum of 74° between 5 and 6 A.M., ascends to 85° at 1 P.M., and then sinks to 76° at midnight. In New Guinea, a little south of the equator, the temperature during the northern summer changes little during the day, but the nights are cold. In June the temperature on the Octanata river, as recorded by Dr. S. Müller in 1828, was 77° in the morning just before sunrise, 84° at noon, and about 78·4° towards evening. These illustrations from tropical localities, and were it necessary many others could be cited, all showing the same general feature, plainly manifest a diurnal thermic periodicity. No exceptions whatever are known. There are differences in the rate and extent of the increase and decrease of the temperature according to locality, but such differences do not in any way obscure the evidence. As a general rule the daily maximum in equatorial regions exceeds the minimum by about 5° on the land, but not more than 2° or 3° on the sea. On the land the maximum is reached between two and three in the afternoon; but at sea, at or soon after midday; while both on land and at sea the minimum occurs a short time before the sun rises. Recurring then to the observations made by Erskine, it may reasonably be conjectured that the 3 P.M. data should be placed not on the rising curve, but on the downward slope just beyond the turn. In other words, the maximum was probably 89° or 90° soon after 2 P.M.

10. In the regions between the tropics and the circumpolar circles the available observations are more numerous, precise, and reliable. A few selected instances need only be given here. Rüppell made observations at Gondar, in Abyssinia, during the winter of 1832–3. The means were 57·5° at 5.40 A.M.; 68·5 at 9.6 A.M.; 75·8° at 12.30 P.M.; and 74·3° at 3.33 P.M. In all probability the maximum was before 3 P.M., but is not shown here; the temperatures at 9 P.M. and midnight are also required to be known for the ascertainment of the true diurnal progression of temperature. At Plymouth the mean annual daily temperature starts from a minimum of 47° Fahr. between 4 and 5 A.M., rises to the maximum of 55° between 1 and 2 P.M., and, declining to 47° at midnight, slowly sinks to the minimum. At the Stonyhurst observatory, Blackburn, in Lancashire, the hour of daily maximum ranges from noon in December to 4 P.M. in June and July, and, indeed, at most places the hour of maximum varies more or less with the length of the day. At Paris the average annual daily temperature is at its maximum at 2 P.M., being 58° Fahr.; the minimum is 44·8° at 4 A.M.; and the mean, 51·3°, occurs at 8.20 A.M. and 8.20 P.M. The observations made by Hayward in January 1869, at Yarkand, in Tibet, gave the following averages:—

Sunrise.	13° Fahr.
9 A.M.	21°
Noon	29°
3 P.M.	31°
6 P.M.	27°
9 P.M.	23°

The time of the minimum, as well as of the maximum, varies according to the length of the day in the middle latitudes; the minimum occurring earlier in proportion as the days lengthen, while the maximum gradually becomes later as the evening light is extended.

11. The evidence harmonises well with what has been stated with respect to the duration of light. All the facts tend to show that the rise and fall of daily temperature is so far dependent upon the presence and position of the sun, and the rotation of the earth upon its axis, that a marked diurnal periodicity is plainly discernible wherever night and day follow each other during each rotation of the earth. In the Polar regions there is a periodicity of the same kind, although it is not so decided as in the lower latitudes. This is shown by the observations made on board the *Erebus* and *Terror* while cruising in the Southern summers of 1841, 1842, and 1843, between 60° and 78° S. lat. The figures are those given by Moseley.

4 A.M.	28·795°
8 A.M.	30·065°
Noon	31·540°
4 P.M.	31·594°
8 P.M	28·956°
Midn.	28·892°

The hours selected were not likely to show the maximum; this probably occurred between noon and 4 P.M., and if anything nearer 4 than noon.

12. The foregoing results are based upon the facts afforded by thermometers placed a short distance above the ground, and therefore must be accepted as applying to that level only; because

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from the investigations of Dines, Hamberg, and Glaisher, as well as from certain casual observations made by meteorologists and others on the appearance and disappearance of clouds, there is known to be a diurnal periodicity in the vertical distribution of temperature, the maxima and minima of which occur at different hours from those already noticed. Nevertheless the evidence is conformable and consistent. The temperature varies with elevation above the ground, and passes through a complete succession of variations in the course of each twenty-four hours. The observations made render it probable, it might be said almost certain, that during the hotter hours of the day the temperature decreases with elevation above the ground, while it increases with elevation during the cooler hours of the night. The rate of increase seems to bear some proportion to the radiation of heat from the ground, while the decrease bears a similar relation to the radiant power of the sun on the ground. According to Dr. Hamberg the lowest strata of the air are the coolest from two to three hours before sunset to at least two or three hours after sunrise. Glaisher infers from observations made by him at different levels from 22 feet above the ground and less that the higher strata are the warmer at night throughout the year in England; that this phenomenon extends to the afternoon hours in March, September, and October, and to all the hours of the day in January, February, November, and December. Burton and other travellers have remarked that the natives of Africa and other countries habitually encamp on slightly elevated spots for the purpose of avoiding the cold of the lower situations, and gardeners have frequently noticed with surprise that, during severe frosts, the plants above a certain height have escaped injury thereby, owing to this law of increase of temperature with elevation under particular circumstances. But the phenomenon evidently extends to greater heights, as is manifested by the frequent gradual increase of clouds from sunrise to 3 P.M., followed by their gradual disappearance until all have vanished, leaving the sky clear at and about sunset.

13. The connection between heat and evaporation is so close that the facts about to be mentioned in illustration of the diurnal periodicity connected with aqueous vapour, would in many instances serve equally well as illustrations of the above indicated diurnal periodicity in the change of rate of alteration of temperature with height above ground. This part of the subject is more complicated and less easy to comprehend owing in part to a paucity of suitable observations, and in part to some of the evidence apparently, but only apparently, pointing to a different conclusion from the remainder. However, as this question of the nature and causes of local differences will be considered when the variations from the general rule are discussed, it need not be further alluded to here. Suffice it to say that the facts confirming or pointing to the existence of a twenty-four hourly period in connection with aqueous vapour are convincing enough, when taken in conjunction with the evidence relative to the other elements, to warrant the belief that the daily periodicities of increase and decrease of humidity, increase and decrease of vapour tension, and of the vertical distribution of the dew point (or rather of the place of maximum humidity), are harmonisable and correlated with those presented by light and heat.

14. The subject of aqueous vapour as an element of climate presents several aspects, each of which should be kept distinct from the others. One is the rate at which the vapour is supplied or, in other words, alternations in the intensity of evaporation; another is the variation in the absolute amount of aqueous vapour in the air; and a third is the changing ratio which this absolute amount may bear to the quantity which would suffice for perfect saturation. It would occupy too long to treat all these, and therefore the distribution of the dew point and of maximum humidity will be selected on account of its affording the most striking exemplification of periodicity. But in order to connect this part of the evidence with that which has gone before, a few lines may be devoted to the data respecting the amount of aqueous vapour in the air. This amount depends upon the temperature, and its variations coincide in the main with those of temperature. The greatest quantity prevails during the hottest hours of the day (provided there is a source of supply of vapour within a moderate distance), while the smallest quantity is found during the coldest hours. The diurnal curve, then, of the amount of aqueous vapour usually agrees with that of temperature. It frequently happens that there is only a moderate source of supply, and then the quantity seems to diminish during the hotter hours. This is owing to the upward diffusion of the vapour and the consequent lessened amount of it in a given bulk of air.

15. The dew point and zone of maximum humidity occur in the coldest section of the vertical column of air. As a rule it is situated on the ground, especially on clear nights, and about sunrise it gradually ascends in the air until it has reached the zone where clouds are usually formed. As the time of maximum cloud occurs some hours after that of maximum dew, the probability is that this zone of maximum humidity gradually ascends from the time of sunrise until it reaches the cloud zone. Towards evening it again descends, reaching the ground when the dew forms, shortly before or shortly after sunset. If this view be correct then analogy would induce us to infer that from this zone of maximum humidity there is an increase of temperature downwards towards the ground and upwards as far, perhaps, as the normal position of the cloud zone. By way of illustration take the following observations made by Flammarion during balloon voyages from Paris, and other places in France. On June 10, 1867, he started from the ground at sunrise, at a time when the horizon was misty, and the fields covered with a fog which gave them the appearance of lakes. The humidity was 93 on the ground, and it increased to its maximum of 98

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at the height of 492 feet. Above that it gradually diminished to 93 at 919 feet, 92 at 984 feet, 86 at 2461 feet and 61 at 4101 feet. On April 18, 1868, an ascent was made from Paris at 3.15 in the afternoon. The humidity on the ground was 73, and increased to 74 at 2546 feet, 75 at 2950 feet, 76 at 3412 feet, and 77 at 3773 feet. This was the maximum, and above this there was a gradual decline to about 30 at the height of 9843 feet. From the observations made during his numerous balloon trips, he concluded that the zone of maximum damp varies in elevation according to the time of the day, season of the year, and other circumstances; and that occasionally it occurs near the surface of the ground, especially at dawn. At Greenwich the result of several years of investigation was that (calling a cloudless sky 0, and one entirely overcast 10), the daily mean was 6·04 at 9.20 P.M., from which time there was a progressive increase as follows:—

11.20 P.M.	6·14
1.20 A.M.	6·41
3.20 „	6·76
5.20 „	6·84
7.20 „	6·89
9.20 „	7·10
11.20 „	7·14

From this time there was a gradual decrease: thus,

1.20 P.M.	7·11
3.20 „	7·00
5.20 „	6·61
7.20 „	6·23

At Rome the period of maximum cloudiness is from noon to 5 P.M. In the tropics during the rainy season the weather is so uniform that almost every day is characterised by the clearness of the sky at sunrise, the appearance of clouds at 10 A.M., their rapid increase till noon when the rain pours for a few hours, generally ceasing about 4, and then the clouds rapidly disperse, allowing the sun to set in unclouded glory. At Lucknow, as Bonavia observed in October, 1877, the clouds appeared day after day in the late morning hours and increased to a considerable extent before 3 P.M. After that hour they dispersed again, but did not quite disappear till about two hours after sunset. In Natal, as Dr. Mann informs us, it is usual for the sky in summer to get cloudy soon after noon, and to be overcast to a late hour at night, when the sky again clears. He also indicates that on the ground the condition of things is the reverse of that in the cloud zone, as the mean humidity at Maritzburg at 9 A.M. for a period of eight years was 71·2; at 3 P.M. it was 60·1, and at 9 P.M. it was 83·4. In the Sahara desert the minimum humidity near the ground occurs at about 2 P.M. Under certain conditions, more especially in localities near large lakes the order of things seems to be different, although a diurnal periodicity is still evident. Thus near lake Tanganyika, Burton states that sunrise is seldom clear, and that, if it is so, clouds gather in the forenoon with the rising wind, but disappear again between noon and 3 P.M., owing, in his opinion, to their being melted by the fervent heat of the sun; but as he also alludes to a marked fall in the wind, this circumstance may have some influence in the matter. Thick mists collect about sunset, and, as a rule, the skies at night are more or less clouded. At Geneva, again, where Plantamour has made observations for upwards of fifty years, the least amount of vapour occurs at sunrise, and the greatest about 2 P.M. during the winter months; whereas, during the summer, there are semi-diurnal periodicities. The morning minimum is shortly before sunrise and the maximum between 8 and 11; the afternoon minimum occurs between 2 and 4 P.M., and the subsequent maximum from 6 to 10 P.M. The precise hour varies according to the season. In the case of the clouds the winter daily maximum is at sunrise and the minimum at sunset. In the summer there is a double periodicity in the twenty-four hours. The morning maximum is shortly after sunrise, and the minimum from 9 to 11 A.M.; in the afternoon the maximum is at about 6 P.M., and the following minimum soon after midnight. Whatever may be the explanation of these curious phenomena, there is still apparent a daily march and an antithetical relationship between the increase and decrease of the humidity at the higher and lower levels.

16. There is a striking coincidence between the cloud changes at Geneva, and the two semi-diurnal barometric periods which are so conspicuously developed in the tropical day. Under the equator the maximum height of the mercury occurs at 9 o'clock, or a few minutes after, and the minimum with equal punctuality at 4 P.M. From this it rises, reaching its second maximum height soon after 10.30 P.M., and its second minimum at 4 A.M. This extreme regularity of barometric movement prevails for several degrees on either side of the equator. This double oscillation is due to the combination of two distinct diurnal periodicities. The one arises from the action of heat and cold in increasing and decreasing the amount of vapour in the air. It follows the same period as the temperature near the ground. Its maximum corresponds with the hottest hours, and causes a maximum of pressure, while its minimum corresponds to a minimum of pressure. On the other hand the air is so acted upon by this same alternation of heat and cold that its maximum of pressure occurs during the coldest hours when the air is densest, and its minimum at the warmest period. The one is the reverse of the other; and there is here a repetition of the antagonistic relationship observable in the diurnal curves of maximum humidity. The two actions give rise to a double barometric oscillation, in which the maxima occur when the two separate pressures are at their mean, and when, therefore, both co-operate in producing pressure, whereas the afternoon minimum barometric pressure is co-temporaneous with the highest vapour tension, while the morning minimum bears the same relation to the highest atmospheric pressure. In accordance with this, it is found that in proportion as

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the absolute amount of aqueous vapour in the air diminishes, or in other words as the vapour tension decreases, so do the amplitudes of the barometric oscillation lessen. Thus there is a gradual diminution in the amplitude from the tropics towards the poles, and from the localities which have the greatest amount of aqueous vapour in the air towards those which have the least. The decrease in the amount of aqueous vapour may arise from two causes, as before mentioned, viz. a diminution of temperature and a diminished rate of supply owing to distance from the ocean and other large bodies of water. Hence the oscillations diminish from summer to winter, from the sea towards the interior of continents, and from the ground upwards. As with temperature and with aqueous vapour, an inverse relationship is noticeable between the fluctuations on the ground and at a definite, but considerable, height above it. From these statements it will be seen how closely interwoven are numerous meteorological subjects, and how a community of causes will account for the variations connected, not only with the period of day, but also with the latitude, the season, and the distance from as well as altitude above the sea. Other explanations have been offered as to the cause of the diurnal barometric oscillations; but the purpose in view here is not to discuss these explanations, or to point out the influences which produce the oscillations; but simply to adduce the best evidence available in favour of the barometric changes being due to a diurnal periodicity. The curve of daily barometric change is so totally different from that of temperature, that no relation seems possible; but a little attention shows that it may really conform with the daily thermic changes, directly in one way and indirectly in another. One or two local instances may represent many examples which could be cited to the same effect, did space permit. At Habana, in Cuba, the precise times of the maxima and minima vary with the seasons; the minima occur at 2.4 A.M., and at 3.4 P.M., and the maxima at 9 to 10 A.M., and at 10 P.M. Ellis says of the diurnal variation at Greenwich, that the morning minimum and the forenoon maximum are latest in summer; and that the changes in the time vary much in the same way as the times of sunrise and sunset vary; so that as the day lengthens, the interval between the forenoon maximum and afternoon minimum increases. The length of the night bears a similar relation to the interval between the evening maximum and morning minimum. At Oxford the mean daily time of the oscillations in May, deduced from observations extending over 16 years, are 3.55 for the first minimum, 7.55 for the first maximum, 4.25 for the second minimum, and 10.45 for the second maximum (Rundell). At Valentia the results for December 1877 were these:—

29·245 in	at 7 A.M.	Min.
29·263 „	„ 11 „	Max.
29·238 „	„ 3 P.M.	Min.
29·273 „	„ 10 „	Max.

At Leh there is a maximum at 9 A.M., and a minimum at about 5 P.M. There is but one diurnal oscillation here, a feature characteristic of places having a dry atmosphere. And as may be noticed the minimum occurs in the afternoon, the period when the atmospheric pressure by itself is presumably least.

17. If then the barometric changes silently declare that they are mainly under the governance of a diurnal period, the winds, which are admittedly dependent, in a great degree, upon the relative distribution of atmospheric pressure, should furnish examples to the same effect. Indeed, as the winds afford a clue to the general state of the atmospheric pressure over large areas, it frequently happens that casual notes on local winds are of material help in deducing conclusions respecting the diurnal barometric period. At maritime places in tropical regions there is a marked uniformity in the order of change of the winds, as has been noticed in other climatal elements. The day breeze commences soon after sunrise, increases in velocity as the heat increases, and ceases about four or five in the afternoon. The lull continues till about sunset, when a light breeze from the opposite quarter sets in, and continues through the night. This phenomenon has been found to exist at a great many sea-side places within and without the tropics. Winds present a second very remarkable periodicity. It has been pointed out by F. Chambers at Bombay. This periodicity presents two minima in the twenty-four hours, and consists of a rotation of the wind direction; which follows, or rather accompanies, the barometric changes. The southerly winds reach their maximum value at the time of the most rapid rise of the barometric curve, while the northerly prevail during the period of most rapid fall. The easterly winds predominate during the maximum, and the westerly during the minimum epochs in the atmospheric pressure. The double wind oscillation is as conspicuous at Calcutta as at Bombay. This oscillation, in conjunction with the alternate increase and decrease of pressure, demonstrates the existence of a daily flux and reflux of air over very wide areas. Rüppell observed something similar at Gondar, in Abyssinia; for, during his stay there, in the rainy season, the wind was N.E. in the morning, veering round to S.E. before 9 A.M., becoming S.W. by noon, and N.W. during the afternoon. At sunset the wind ceased. At Pola, in Illyria, there is a daily variation in the direction of the wind; it starts from a point E. of S. at 5 A.M., and gradually veers till it reaches its most westerly point about 6 P.M., from which time it shifts back to its starting point. The wind force also shows a diurnal periodicity. Thus at Pola the force is nearly double as strong from 11 A.M. to 6 P.M. as it is from 9 P.M. to 6 A.M. The elaborate observations by Osler at Birmingham give the following interesting results. In winter the force of the wind undulates about 220 from midnight until 8 A.M., rises to a maximum of 390 at 1 P.M., sinks to 350 at 7 P.M., and then declines till midnight. In the

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spring it starts from 90 early in the morning, reaches the maximum of 300 at 1 P.M., sinks rapidly to 160 at 6 P.M., and then more slowly to 90. In the summer the rise is from 70 in the morning to 260 at 3 P.M.; and then a fall to the minimum. In the autumn the maximum of 260 is reached at 2 P.M. Many lakes have their morning and evening breezes, which sometimes blow with such astonishing regularity as almost to constitute a measure of time, as for instance on the Te Anau lake in New Zealand (McKerrow). At Geneva the daily fluctuations of the land and lake breezes are of a decided character. Plantamour has found that in December, when there is no perceptible difference in the temperature of the land and the lake, there is no prevalent lake breeze. In January the lake breeze sets in, and increases from month to month as the days lengthen and the temperature increases. The wind presents a periodicity in its other aspects, such as the time when violent storms commence. At St. Blaise, in Switzerland, the Peters family carefully noted the particulars respecting 260 storms of wind. Only sixteen of these began between 4 A.M. and noon, while 135 were initiated between noon and 8 P.M., and 70 between 8 P.M. and 4 A.M.

18. Inclination would induce us to give the confirmatory details afforded by the diurnal periodicities of rainfall, thunderstorms, distribution of the maximum and minimum intensity of atmospheric electricity, hailfall, ozone, and the chemical action of light. There is an abundance of material for this; but we refrain from further consideration of the subject, in order that we may avoid exhausting the patience of the reader.

19. The conclusions to be drawn from the foregoing facts are: that each element of climate is liable to a regular daily change, primarily dependent upon the earth's rotation and the consequent exposure to the sun, the amount and degree of which varies with every locality; that in some the increment and decrement constituting the period is regulated by the light or heat, so that the maximum is attained soon after the hottest hours; that in others the period is regulated by the action of heat converting water into vapour, so that the maximum is produced during the coldest hour of the day; that the hour of greatest heat or of greatest cold differs according to the height above the ground, causing a vertical oscillation of the period between the ground and the cloud zone; and, lastly, that when heat alone and heat acting by the agency of aqueous vapour, co-operate, the maximum effect produced by each separately is so counteracted by the other, that the combined result of their co-operation is to produce a minimum effect, while the maximum occurs when each is at its mean and both act together; the result of which is an apparent double maximum in the course of the day. The maze of changes may seem very confused; but, in reality, however complicated the arrangements are, all is in perfect order. Thus having completed the round, the mind recurs to the subject which occupied our thoughts in the opening paragraphs of this essay.

A. R.

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GENERAL REMARKS.

In these notes the term general has an indefinite as well as a definite meaning. It includes, as it should do, titles and facts which relate to climate generally, such as "On the Uniformity of Insular Climates;" and, in the case of districts, those which apply generally to them, such as "The Meteorology of Holland." There are many titles which are expressed generally, but which manifestly apply to some particular district; as, for instance, "Meteorological Abstract for the Years 1794–1799." As the special district is not stated, such papers, etc., are entered here; when they have been read the titles are repeated under the name of the districts to which they relate. Particulars respecting the application of telegraphy to meteorological purposes, broad references to cycles, propositions for organised methods of research, notices of the healthiness or unhealthiness of places, are considered to be general. In addition to these there are items which cannot be regarded as general, but which, owing to their vagueness, cannot be definitely placed; so that the only position for them is under general. One instance of this is Fothergill's paper in this number (1805, 2), which may seem to be quite out of place. The only reason for putting it here is the "etc." When this paper has been read, the facts represented by "etc." will be entered in their proper places; but in the meanwhile it is considered to be indefinitely general. Again, certain papers and facts are entered under general, about which there is great uncertainty as to whether they are meteorological at all, as for instance, blood rain, black rain, red snow, showers of frogs, and other strange objects, and similar subjects. Papers of this kind often contain some meteorological data. Remarks on storms of the character of which no specific mention is made are grouped as general. The atmosphere is considered to be distinct from climate; consequently facts relating to its physical and chemical qualities, which do not concern climate, are not to be found here, but under the section devoted to atmosphere. The papers and paragraphs are numbered so as to facilitate reference. As a matter of convenience the volumes of a serial are entered under the year of publication, but when the date is lumped, and the volumes have not been examined for the purpose of ascertaining the year of issue of each volume, the serial is assigned to the general section subordinate to Bibliography. Descriptions of instruments are not considered to be meteorological, except when the statements made bear upon recorded readings. When the volume has a date extending over one year, the title is placed under the latest year mentioned.

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GENERAL BIBLIOGRAPHY.

Date unknown.

1. Speculum vel Imago Mundi. A portion of the work is devoted to meteorology. It was written in the 13th century. The French prose translation of it is dated 1464; and Caxton printed an English translation with the title 'Image or Mirror of the World.'

1485.

1. Prognosticon. Venice.

1670.

1. **Fromondi, Libertus.** Meteorologicorum Libri sex. 8vo. London.

1785.

1. **Swinden, J. H. van.** Observations sur quelques particularités météorologiques de l'année 1783. Mém. Acad. Turin, ii. p. 113–140 (1784–5).

1789.

1. **Franklin, B.** Meteorological imaginations and conjectures. Mem. Phil. Soc. Manchester, ii. p. 373–376.

1790.

1. **Monge, G.** Sur la cause des principaux phénomènes de la météorologie. Annal. de Chimie, v. p. 1–71.

1793.

1. **Kirwan, R.** Reflections on meteorological tables, ascertaining the precise signification of the terms wet, dry, and variable. Trans. Irish Acad., v. p. 31–38.

1796.

1. **Garnett, Thos.** Meteorological observations collected and arranged. Mem. Phil. Soc. Manchester, iv. p. 517–640.

1797.

1. **Lamarck, J. P. B. A. de M., Chev. de.** De l'influence de la lune sur l'atmosphère terrestre. Bull. Soc. Philom. Paris, i. p. 116–118.

2. **Saussure, H. B.** A memoir concerning a remarkable phenomenon in meteorology. Nicholson, Journal, i. p. 511–513.

1798.

1. **Playfair, J.** Meteorological abstract for the years 1794–1796. Trans. Edin. Roy. Soc., iv. p. 213–222.

1799.

1. **Gronau, C. L.** Ueber die Witterung der Jahre 1782. N. Schr. Ges. Nat. Freunde Berlin, ii. p. 278–291.

2. **Saussure, H. B.** A memoir, etc. [as in 1797, 2]. Gilbert, Annalen, i. p. 317–322.

3. **Toaldo, Giuseppe.** System respecting the probability of a change of weather at the different changes of the moon. (From Journ. des Sciences utiles). Phil. Mag., iii. p. 120–127.

4. **Toaldo, G.** On the signs exhibited by animals which indicate changes of the weather, with remarks on their prognostications. Phil. Mag., iv. p. 367–375.

5. **Voigt, J. H.** Ueber die Starke des Schalles in Beziehung auf die Meteorologie. Voigt, Magazin, i. p. 75–80. (Heft 4.)

1800.

1. **Cotte, L.** Meteorological axioms. Phil. Mag., vi. p. 146–152.

2. **Humboldt, F. H. A. von.** Lettre renfermant des observations astronomiques, nautiques et météorologiques. Bull. Soc. Philom. Paris, ii. p. 98–101; 109–111.

2. **Lamarck, J. P. B. A. de M., Chev. de.** De l'influence de la lune sur l'atmosphère terrestre. Gilbert, Annalen, vi. p. 204–223. Nicholson, Journal, iii. p. 488–489.

3. **Voigt, J. H.** Ueber die Beschaffenheit der Atmosphäre in Beziehung auf die Gesundheit unseres Körpers. Voigt, Magazin, ii. p. 568–579.

1801.

1. **Gronau, C. L.** Ueber die Witterung der Jahre 1782. N. Schr. Ges. Nat. Freunde Berlin, iii. p. 124–149.

2. **Lamarck, J. P. B. de M., Chev. de.** Recherches sur la périodicité présumée des principales variations de l'atmosphère, et sur les moyens de s'assurer de son existence et de sa détermination. Journ. de Phys., lii. p. 296–316.

3. **Treviranus, G. R.** Galvanisch-meteorologische Ideen. Gilbert, Annalen, viii. p. 129–131.

4. **Wrede, E. F.** Ueber den sogenannten fliegenden Sommer. N. Schr. Ges. Nat. Freunde Berlin, p. 537–554.

1802.

1. **Beddoes, Thomas.** Letter on prognostics of the weather, the effects of the nitrous oxide, and other objects. Nicholson, Journal, i. p. 98–100.

2. **Cotte, L.** Note relative au Mémoire intitulé: 'Suite des recherches relatives à l'influence de la lune sur les variations de l'atmosphère en

Digitized by Google

général et sur celles du baromètre en particulier.' Journ. de Phys., lv. p. 197–198.

3. **Lamarck, J. P. B. A. de M., Chev. de.** Sur les variations de l'état du ciel dans les latitudes moyennes entre l'équateur et le pôle, et sur les principales causes qui y donnent lieu. Journ. de Phys., lvi. p. 114–138.

4. **Parrot, G. F.** Umwandlung der Hygrologie une Meteorologie; verbesserter Phosphor-Oxygenometer; über das Phosphor-Eudiometer; und Mittel Gewitter unschädlich zu machen. Gilbert, Annalen, x. p. 166–218, 489; xi. p. 66.

5. **Woodhouse, James.** Experiments and observations on the vegetation of plants, which show that the common opinion of the amelioration of the atmosphere by vegetation in solar light is ill-founded. Nicholson, Journ., ii. p. 150–162.—Annal. de Chimie, xliii. p. 194–312.

1803.

1. **Gronau, C. L.** Ueber die Veränderungen des Klimas in verschiedenen Gegenden. N. Schr. Ges. Nat. Freunde Berlin, ix. p. 56–69.

2. **Langgutti, C. A.** Magnetische und meteorologische Beobachtungen. Gilbert, Annalen, xiii. p. 374–378.

3. **Parrot, G. F.** Umwandlung, etc. [as in 1802, 4]. Gilbert, Annalen, xii. p. 332–334.

4. **Woodhouse, J.** Experiments, &c. [as in 1802, 5].

1804.

1. **B., R.** Prognostics of the weather established by long continued observations upon the product and appearances of birds, beasts, insects, plants, meteors, the heavenly bodies, and minerals. Nicholson, Journal, vii. p. 148–157.

2. **Biot, J. B., et Gay-Lussac.** Relation du voyage aërostatique. Journ. de Phys., lix. p. 314–320.—Phil. Mag., xix. p. 371–379.

3. **Cotte, L.** Sur les périodes météorologiques. Bibl. Britannique, xxvii. p. 74–79.

4. **Frisi, Paul.** Mémoire sur les influences météorologiques de la lune. Mém. Acad. Marseille, iii. pp. 65, 95.

Gay-Lussac. See 1804, 4.

4. **Prevost, Pierre.** Lettre à l'occasion des rapprochements météorologiques du P. Cotte. Bibl. Britannique, xxvii. p. 163–167.

1805.

1. **Biot, J. B., et Gay-Lussac.** Relation du voyage aërostatique. Gilbert, Annalen, xx. p. 18.

2. **Fothergill, A.** Observations and experiments on the extraordinary degree of cold at Northampton (England) during the extreme frost of 1776–7; with remarks on the climate of London, Philadelphia, etc. Philad. Med. Phys. Journ., ii. p. 5–20.

Gay-Lussac. See 1805, 1.

3. **Playfair, J.** Meteorological abstract for the years 1794–1799. Trans. Edin. Roy. Soc., v. p. 193–202.

4. **Ritter, J. W.** Noch einiges über Nordlichten, Feuerkugeln, und auffallende meteorologische Wahrnehmung am 20sten Nov. 1804. Gilbert, Annalen, xx. p. 235–242.

5. Des influences météorologiques sur la vigne. Bibl. Britannique (Agric), ix. p. 139–152.*

1806.

1. **Multedo.** Memoria meteorologica. Mem. Ist. Ligure, Genova, i. p. 221–236.

1807.

1. **Cotte, L.** Tableau chronologique des principaux phénomènes météorologiques observés en différens pays depuis 37 ans (de 1774 à 1810) et comparés avec les températures correspondantes du climat de Paris. Journ. de Phys., lxv. p. 161–168; 329–364.

2. **Lamarck, J. P. B. A. de M., Chev. de.** Etwas über die Meteorologie. Gilbert, Annalen, xxvii. pp. 355–359.

3. **Salisbury, R. A.** An account of a storm of salt which fell in Jan. 1803. Trans. Linn. Soc., viii. p. 286–290.—N. Bull. Soc. Philom. Paris, i. p. 188.

4. **Vassalli, Eandi, A. M.** Saggio d'un trattati di Meteorologia. Mem. Soc. Ital. Modena, xiii. p. 85–100.

1808.

1. **Gronau, C. L.** Ueber die Winter nach hundert und mehrjährigen Beobachtungen. Mag. Ges. Nat. Freunde Berlin, ii. p. 31–39.

2. **Gronau, C. L.** Hat der Mond wirklich den Einfluss auf die Witterung, den man ihm von jeher zuschrieb? Mag. Ges. Nat. Freunde Berlin, ii. p. 101–106.

3. **Gronau, C. L.** Ueber die Frühlinge nach hundert und mehrjährigen Beobachtungen. Mag. Ges. Nat. Freunde Berlin, ii. p. 230–234.

4. **Gronau, C. L.** Ueber die Sommer nach hundert und mehrjährigen Beobachtungen. Mag. Ges. Nat. Freunde Berlin, ii. p. 313–316.

5. **Heinrich, P.** Einige Bemerkungen über die diesjährigen Witterung. Gehlen. Journ., v. p. 726–729.

6. **Robertson, Dr. H.** A general view of the Natural History of the atmosphere and of its connection with the sciences of Medicine and agriculture, including an essay on the causes of epidemical diseases. 2 vols. 8vo. Edin. (Lib. Met. Soc.)†

7. **Salisbury, R. A.** An account of a storm of salt which fell in Jan. 1803. Brugnatelli, Giornale, i. p. 439–440.—Gehlen, Journal, vii. p. 508–509.

8. **Vitalis, J. B.** Dissertation de la météorologie et les observations météorologiques. Trav. Acad. Rouen, p. 148–162.

1809.

Cotte, L. Tableau chronologique, etc. [as in 1807, 1]. Journ. de Phys., lxviii. p. 331–335.

2. **Dunbar, William.** Meteorological observations for the year 1800 with remarks upon

* Papers without authors' names are anonymous.

† Items so marked are in the library of the Meteorological Society of London. The titles are taken in most cases from the Society's catalogue.

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the state of the weather, vegetation, etc., calculated to give some idea of the state of the climate. Trans. Am. Phil. Soc., vi. p. 43–54. —Gilbert, Annalen, xxxi. p. 421–434.

3. **Gronau, C. L.** Ueber die Herbste nach hundert und mehrjährigen Beobachtungen. Mag. Ges. Nat. Freunde Berlin, iii. p. 47–51.

4. **Hermbstädt, S. F.** Ueber den schnellen Wechsel der Witterung zwischen den 26 u. 27 Januar, 1809. Mag. Ges. Nat. Freunde Berlin, iii. p. 237–240.

5. **Mons, G. B. von.** Sur des phénomènes météorologiques et l'usage de quelques instruments. Brugnatelli, Giornale, ii. p. 317–323.

6. **Mons, G. B. von.** Extract of a letter on Atmospheric Phenomena. Nicholson, Journal, xxiv. p. 106–114.

7. **Salisbury, R. A.** An account, etc. [as in 1807, 3]. Gilbert, Annalen, xxxi. p. 98–100.

1810.

1. **Bostock, John.** Remarks upon Meteorology with a specimen of a new meteorological table. Nicholson, Journal, xxv. pp. 196–208; xxvi. p. 1–9.

2. **Cotte, L.** Tableau chronologique, etc. [as in 1807, 1]. Journ. de Phys. lxx. p. 199–205.

3. **Forster, Thomas.** Remarks on Meteorology. Nicholson, Journal, xxv. p. 259–260.

4. **Gronau, C. L.** Die Witterung der Jahre 1809–1811. Mag. Ges. Nat. Freunde Berlin, iv. p. 149–155.

5. **Heller, J. E.** Läst sich am mehrjährigen meeorolo gischen Beobachtungen eine Regel finden nach welcher man die grössere oder geringere Fruchtbarkeit vorhergegangener Jahre beurtheilen konnte. Annal. Wetterau Gesells., ii. p. 164–169.

6. **Hombres-Firmas, L. A. d'** Résultat des observations météorologiques. Notice Trav. Acad. Gard, p. 113–115.

1811.

1. **Gronau, C. L.** Die Witterung der Jahre 1809–1811. Mag. Ges. Nat. Freunde Berlin, v. p. 91–98; 410–418.

2. **Gronau, C. L.** Das Klima der nordlichen Polarländer. Flörke Repert., i. p. 340–354.

3. **Walther, F. L.** Die Jahreszeiten, eine physicalische Betrachtung. Wetterau Gesells. Ann., ii. p. 296–304.

1812.

1. **Gerdum, C. D.** Ueber seine Bemerkungen um die Witterungskunde. Gilbert, Annalen, xli. p. 426–444.

2. **Gray, W. J.** Meteorological table for 1811. Nicholson, Journal, xxxii. pp. 73, 74.

3. **Gronau, C. L.** Die Witterung der Jahre 1809–1811. Gilbert, Annalen, xli. p. 99–109.

4. **Pearson, F.** Remarks on some useful applications of meteorological observations to nautical prophylactics. Nicholson, Journal, xxx. p. 54–66.

1813.

1. **Young, Thomas.** An essay upon the medical effects of climate. Phil. Mag., xli. pp. 210–214; 255–263.

2. Osservazione meteorologiche, mediche ed agrarie. Mem. Accad. Agric. Verona, vi. pp. 103–220; 221–233.

1814.

1. **Horner, J. K.** Blutregen. Gilbert, Annalen, xlvii. p. 98–103.

2. **Séguin, Armand.** Mémoire sur la salubrité et l'insalubrité de l'air atmosphérique. Ann. de Chimie, lxxxix. p. 251–272.

1815.

1. **Cagnoli, Antonio.** Osservazione meteorologiche. Mem. Accad. Agric. Verona, vi. p. 7–101 (1815).

2. **Gilbert, L. W.** Einige orientalische Nachrichte von meteorischen und Eisen-massen, von Frosch-und Fisch-regen, u. s. w. Gilbert, Annalen, l. p. 277–300.

3. **Griscom, John.** Hints relative to the most eligible method of indicating meteorological observations. Trans. Lit. and Phil. Soc. New York, i. p. 350–354.

4. **Linussio, L. L.** Sur une phénomène météorologique. Bibl. Britannique, lx. p. 391–392.

5. **Prud'homme.** Exposition des effets météorologiques de l'air. Caen, Travaux, p. 135–147 (1811–1815).

6. Osservazione, etc. [as in 1813, 2]. Mem. Accad. Agric. Verona, vii. pp. 47–393; 399–400.

1816.

1. **Brandes, H. W.** Auszüge aus Briefe über Meteorologie. Lindenau, Zeits., ii. p. 440–447.

2. **Forster, Thomas.** Notes of a Meteorological tour. Phil. Mag., xlviii. p. 8–14.

3. **Gronau, C. L.** Die Witterung der Jahre 1812–3. Mag. Ges. Nat. Freunde Berlin, vi. p. 243–249; vii. p. 277–283.

4. **Singers, Rev. Wm.** Essay on the varieties of wheat, barley, oats, peas, and beans, and on the distinguishing properties by which they are adapted for culture in different soils, places, and climates. Trans. Highland Soc., iv. p. 66–115.—Bibl. Univ., i. (Agric.) p. 130–148.

5. **Stockton, James.** On the horse-leech as a prognosticator of the weather. Thomson, Ann. Phil., viii. p. 450–454.

1817.

1. **Brandes, H. W.** Meteorologischen Inhalts. Gilbert, Annalen, lv. p. 112–114.

2. **Ehrenheim, F. W.** Disquisitiones meteorologicæ. Nova Acta Soc. Sci. Upsala, ix. p. 291–323.

3. **Reuss, F. A.** Ueber den Einfluss einer herrschenden Luft-und Witterungsbeschaffenheit auf das Entstehen, Vorbereiten und Erlöschen der Volkskrankheit. Hufeland u. Harles, Journ. Arzn., xlv. (Heft 2) p. 3–105.

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4. **Volta, A.** Sul periode de' Temporali e sul vento freddissimo ed istraordinariamente secco che si fa sentire molte ore dopo e quelle che scaricarone grandine. Brugnatelli, Giornale, x. p. 17–27.—Annal. de Chimie, iv. p. 245–249.—Gilbert, Annalen, vii. p. 341–359.—Schweigger, Journ., xix. p. 262–280.

1818.

1. **Gerdum, C. D.** Die Entdeckung von sechs neuen Hauptplaneten in unserm Sonnensysteme auf meteorologische Wege. Oken, Isis. col. 24–29.

2. **Gronau, C. L.** Ueber die Witterung der Jahre 1814–1816. Mag. Ges. Nat. Freunde Berlin, viii. pp. 19–23; 224–226; 259–269.

3. **Olbers, W.** Ueber den Einfluss des Mondes auf die Witterung. Lindenau, Zeits., v. p. 234–244.

4. **Z., A.** On the influence which the increase or diminution of the Polar Sea has on the climates of other latitudes. Phil. Mag., li. p. 199–200.

5. Résumé des principaux évènements météorologiques qui ont agité l'atmosphère pendant la première quinzaine de mars. Bibl. Univ., vii. p. 243–248.

1819.

1. **Brandes, H. W.** Einige Resultate der Witterungs Geschichte des Jahres 1783, und Bitte im Nachrichten aus jener Zeit. Gilbert, Annalen, lxi. p. 421–426.

2. **Castellani.** Considerations sur les observations météorologiques. Bibl. Univ., x. p. 168–173.

3. **Hammett, John.** Remarks on Madeira; climate of the tropics, Rio Janeiro, etc. Phil. Mag., liv, p. 107–117; 194–198.

4. **Olbers, W.** Ueber, etc. [as in 1818, 3]. Ann. Bureau des Longitudes, p. 188–194.

1820.

1. **Brandes, H. W.** Vorschlage zur Witterungs-beobachtungen. Schweigger, Journ. xxix. p. 261–274.

2. **Clarus, J. C. C.** Der Gewitter Orkan am 8 Juli, 1819, und einiges zur Naturgeschichte des Gewitters. Gilbert, Annalen, lxv. p. 83–100.

3. **Muncke, J, W.** Eine einfache Witterungs Regel. Gilbert, Annalen, lxv. p. 214–215.

4. **Murray, John.** On the uniformity of insular climates. Thomson, Ann. Phil., xvi. p. 231.

1821.

1. **Arago, D. F. J.** Sur une matière gelatineuse tombée de l'atmosphère. Ann. de Chimie, xix. p. 67.

2. **Bellasis, A.** Annotazioni di meteorologica. Brugnatelli, Giornale, iv. p. 339–344.

3. **Buton, Pierantonio.** Memoria Meteorologica. Atti Accad. Lucca, i. p. 287–293.

4. **Castellani.** Einige meteorologische Bemerkungen. Gilbert, Annalen, lxvii. p. 212–214.

5. **Howard, L.** On the best means for constructing meteorological observations at different places and climates so as to produce some uniformity in the modes of attaining and summing up the results. Phil. Mag., lvii. p. 81–83.

6. **Olbers, W.** Ueber, etc. [as in 1818, 3]. Annal de Chemie, xix. p. 208–217.

6. **Tristan, Jules de.** Tableau des époques de la végétation et observations météorologiques pendant l'année 1819. Orléans, Annal, iii. p. 6–30.

7. Account of a shower of snails. Phil. Mag., lviii. p. 310–311; p. 457–458.

1822.

1. **Clarus, J. C. C.** Beobachtungen der Witterung des Jahres 1821. Schr. Nat. Gesells Leipzig, i. p. 233.

2. **Daniell, J. F.** Meteorological Observations. Q. Journ. Sci., xii. p. 97–114.

3. **Flaugergues, H.** Note sur la constitution météorologique de l'année 1821. Journ. de Phys., xciv. p. 67–72. Gilbert, Annalen, lxxii. p. 75–82.

4. **Gorno, P.** Sui temporali. Comment. Ateneo Brescia, p. 34–41.

5. **Hailstone, J.** Some observations on the weather accompanied by an extraordinary depression of the barometer during the month of Dec. 1821. Trans. Phil. Soc. Cambridge, i. p. 453–458.

6. **Hoppe, D. H.** Betrachtungen über die Witterungs des Jahres 1821 und über ihren Einfluss auf die Vegetation. Flora, v. p. 195–201.

7. **Schouw, J. F.** Kort vejledning til at anstille meteorologiske iagttagelser. Oersted. Tijdsskrift, i. p. 269–293.

8. **Tristan, J. de.** Tableau, etc. [as in 1821, 6].

9. **Wauchope, R.** Meteorological and hydrographical notes. Mem. Wern. Soc. Edin., iv. p. 161–172.

1823.

1. **Esmark, J.** Meteorologische Beobachtungen. Astr. Nachr., i. col. 167–168.

2. **Forster, T.** Researches about atmospheric phenomena. Third edition: with a series of engravings illustrative of the clouds, etc.; to which is added the calendar of Nature, 8vo. London. (Lib. Met. Soc.)

3. **La Place, P. S., Marquis de.** De l'action de la lune sur l'atmosphère. Annal de Chimie, xxiv. p. 280–294.

4. **Posselt, J. F.** Bemerkungen und Beobachtungen über Witterungskunde. Froriep, Notizen, iii. col. 1–10.

1824.

1. **Beaufoy, M.** An account of some observations made during a late aerial excursion. Thomson, Ann. Phil., viii. p. 209–212.

2. **Brandes, H. W.** Zur Meteorologie. Kastner, Archiv Naturl., ii. p. 394–412.

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3. **Gutmann.** Theorie über die Wahrscheinlichkeit in der Witterungskunde. Verhand. Schweiz. Gesells., p. 26–27.

4. **Kastner, K. W. G.** Zur Meteorologie. Kastner, Archiv Naturl., i. p. 293–309.

5. **Meyer, G. F.** Osservazioni meteorologiche. Mem. Acad. Agric. Verona, x. pp. 63–101; 199–218; 231–239; 257–270; 301–325.

6. **Schön.** Briefliche Mittheilungen meteorologischen Inhalts. Kastner, Archiv Naturl., i. p. 313–319.

10. **Tomaselli, J.** Osservazione meteorologiche. Mem. Accad. Agric. Verona, x. p. 5–64.

1825.

1. **Adie, Alexander.** Account of some of the rarer atmospherical phenomena observed in 1824. Edin. Journ. Sci., iii. p. 49–59.

2. **Beaufoy, M.** An account, etc. [as in 1824, 1]. Froriep, Notizen, ix. col. 1–6.

3. **Brandes, Rud.** Mittheilungen meteorologisch-chemikalischen Inhalts. Kastner, Archiv Naturl., iv. p. 241–250.

4. **Costa, O. G.** Relazione del P. D. Giuseppe Piazzi sul giornale meteorologica, economia e campestre. Atti Accad. Sci. Napoli, ii. p. 19–24.

5. **Crichton, Sir A.** On the climate of an antediluvian world, and its independence of solar influence; and on the formation of granite. Thomson, Ann. Phil., ix. pp. 97–108; 207–217.

6. **Crichton, Sir A.** Sur le climat du monde antediluvien, sur son independence de l'influence solaire, et sur la formation du granite. A. des Sci. Nat. Zool., v. pp. 391–428.

7. **Daniell, J. F.** Meteorological Observations. Froriep, Notizen, ix. cols. 33–37.

8. **Quetelet, L. A. J.** Moyen d'apprécier approximativement la hauteur à laquelle apparait une phénomène météorologique. Quetelet, Corresp. Math., i. p. 73–77.

9. **Schön.** Ueber die diesjährige Frühlingswitterung. Kastner, Archiv Naturl., v. p. 363–370.

1826.

1. **Boué, Ami.** Geol. Observations, 1–3. 4. On the climate of the globe. Edin. New Phil. Journ., i. p. 82–92.

2. **Crichton, Sir A.** On the, etc [as in 1825, 5]. Froriep, Notizen, xii. cols. 225–234; 241–249.

3. **Daniell, J. F.** On climate considered with regard to agriculture. Trans. Hort. Soc., vi. p. 1–28.—Gill, Techn. Repert., ix. p. 166–172.—Thomson, Ann. Phil., xi. p. 114–130.

4. **Daniell, J. F.** Correction of an error in the Meteorological Essays. Q. Journ. Sci. xx. p. 74–78.

5. **Dewey, Chester.** Meteorological observations. Am. Journ. Sci., xi. p. 59–61.

6. **Flaugergues, H.** Observations météorologiques. Zach, Corr., xiv. p. 260–268.

7. **Gazzaniga, C. L.** Saggio di un metodo per registrare de osservazione meteorologiche al fine de deduire, con maggiori probabilita, i correspondenti pronostici. Brugnatelli, Giornale, ix. p. 146–151; 218–235.

8. **Hertzberg, Nils.** Fortsättelse af meteorologiska lagt-tagelser. Mag. f. Naturvid., vii. p. 122–148.

9. **La Place, P. S.** Marquis de. De l'action de la lune sur l'atmosphère. Connaiss. des Temps, p. 308–317.

10. **Schouw, J. F.** Om Klimaternes formeentlige Forandring. Afh. Dansk. Vid. Selsk. Kiöbnhavn, ii. p. xxxix–xliv.

11. **Schwarzenbrunner, B. J.** Meteorologische Beobachtungen. Astr. Nachr., iv. cols. 153–156.

12. **Wrede, E. F.** Ueber die scheinbare Lage paralleler Strahlen in der Atmosphäre und ihre Anwendung zu meteorologischer Messungen. Pogg. Annalen, vii. pp. 217–224; 305–310.

1827.

1. **Boué, Ami.** Geol. Observations. 1–3. 4. On the climate of the globe. Leonard, Zeits., p. 316–321.

2. **Buton, P.** Memoria meteorològica degli anni 1817, 1818, 1819, 1820. Atti Accad. Lucca, iii. p. 107–134.

3. **Claridge, J.** The Shepherd of Banbury's Rules to judge of the changes of the Weather grounded on forty years' experience; by which you may know the weather for several days to come and in some cases for months. To which is added a rational account of the causes of such alterations, the nature of wind, rain, snow, etc. London (Lib. Met. Soc.).

4. **Deribier de Cheissac.** Rapport sur un Mémoire de M. Morin, ayant pour titre 'Correspondance par l'avancement de la Météorologie. Ann. Soc. Agric. Le Puy, p. 76–81.

5. **Ehrenheim, F. W.** Sammandrag af de till K. Vet. Acad. inkomna meteorologiska observationer för åren 1826 och 1827. Acad. Handl. Stockholm, p. 181–189.

6. **Guillaume.** De l'influence de la lune sur les saisons, les plantes, et les animaux. Ann. Soc. Agric. Le Puy, p. 81–87.

7. **Forster, T.** The Pocket Encyclopædia of Natural Phenomena; being a compendium of prognostications of the weather, signs of the seasons, periods of plants and other phenomena in natural history and philosophy; compiled principally from the manuscripts and MS. Journals of the late T. Forster, F. L. S., etc. 8vo. London (Lib. Met. Soc.).

8. **Schön.** Ueber meteorologische Beobachtungen. Kastner, Archiv Naturl., x. p. 129–254.

9. **Schübert, G.** Meteorologische Notizen, insbesondere über Bestimmung mittlerer Temperaturen. Schweigger, Journ., xlix. p. 121–131.

1828.

1. **Barros.** Dissertation sur la météorologie. 4to.

2. **David, Aloys.** Resultate aus der Witterungs Beobachtungen Neue Schriften, Prag. i. (1) p. 103–156; (2) pp. 109–120; 133–150.

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rising barometer; but in a secondary the barometer is usually perfectly stationary with a slight but quick motion at the beginning and end of the rain, either up or down, according to the general direction of barometric change. This heavy rain and cloud, with a steady barometer, was long very puzzling, and it is only since the publication of the carefully-drawn charts of the Meteorological Office that its true nature has been (*Page* 8) discoverable. In anti-cyclones viewed on a synoptic chart, the position of blue sky, cloud or fog seems very capricious, but to a single observer a certain general character is readily perceptible; but as it is much less marked than that in cyclones, it is more easily masked by diurnal, local, and seasonal variations. In a general way the weather is fine or at least quiet; and though, in the calm centre especially, thick fogs are often found, and cloud in other parts, the surroundings are so different, that they can rarely be mistaken for cyclone weather. There is always a certain coolness in the air, though if the sun shines it is very hot; in fact the terms "radiation weather" and "radiation temperature" would generally best describe anti-cyclonic weather. There is no doubt that in this country rain sometimes falls in an anti-cyclone, and in France it seems to be tolerably common. To a single observer the rain is usually in short showers, with rather a high sky, and the general appearance is different from that in either primary or secondary cyclones; the showers are very often accompanied by a slight irregular motion of the barometer, and as they are very short and of small extent are probably due to some local disturbance. [Illustrations are given of the general principles from the weather prevailing on specified days in various parts of the British (*Page* 12) Isles and contiguous area. The addition referred to below was made in March.] The following are additional illustrations of the term intensity as applied to weather. (*Page* 13) Take a cyclone of a certain size and shape, and conceive another of the same size and shape moving in the same direction at the same rate, but in which the isobars, instead of representing a difference of ·2in., represent a difference of only ·1in., then we should have two cyclones differing in nothing except intensity, which would be greater in the first than in the second. The corresponding difference of weather would be shown in a less continuous area of rain near the centre, in a smaller extension of cloud round the rain, and in a less total rainfall all over the country during the cyclone's motion. Where squalls occurred in the first cyclone they would be replaced in the second by brisk showers, and the weather generally would be more deficient in those properties to which the words hardness or severity are usually applied, but the general character and position of the front and rear would remain unaltered. Thus we see that this kind of intensity depends on the steepness of the gradients in a single cyclone. The other kind of intensity refers rather to that sequence or tract of weather to which the term broken would be applied. From synoptic charts broken weather is found to be either the product of small quick-moving cyclones, which only exist a very short time, or of frequent secondaries; in contradistinction to the weather produced by large shallow-gradient cyclones, moving slowly and lasting some days, which would be associated with more settled weather. The difference between these two kinds of intensity is analogous to single heavy gusts of wind being as much a sign of great atmospheric disturbance as numerous short puffs, although they proceed from different causes. With regard to the line dividing the front and rear of a cyclone, it can always be approximately determined by drawing a series of sections of pressure across the cyclone, parallel to its path. The line along which each of the sections changes from rise to fall is the line required, and is obviously independent of the deepening or filling up of the cyclone. Sometimes when a cyclone is filling up very rapidly the barometer rises even when the central line is approaching the observer; and conversely, when a cyclone is deepening rapidly the barometer continues to fall after the central line has passed, but the relation of wind and weather, relative to the cyclone centre, always remains the same. In this fact we have the explanation of many seeming anomalies between the apparent motion of the barometer and the actual state of the weather,

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INDEX.

THE Index to the present part is only a subject index. The Conductor would have desired the addition of indexes of persons, places, and time; but as these would occupy more space than it seems advisable to allow, he has not ventured to give them. If there should be any call for such indexes an attempt will be made to supply them. From the nature of the notes many cannot be referred to in the index. And as regards the index itself, it is to be noticed that it is a tentative effort to base the entries on the subject of the papers rather than upon catchwords occurring in the titles. There are, doubtless, many errors and defects; but while there is no intention to make any excuse for these, still it may be observed that difficulties are often caused by the indefinite, or rather ill-defined, nature of the titles. These difficulties are, however, just the same whether catchwords are or are not used.

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AQUEOUS VAPOUR: NOTES.

1823.

Daniell, J. F. *Concluded from page* 219.

(*Page* 62) We must now provide some obstacle by which the course of the vapour may be retarded in its ascent; then may the condensation take place gradually and at different heights. The relative distances of these points of precipitation will depend upon the force of the vapour, and the greater or less facility with which it overcomes the mechanical obstruction. For the scale of temperature laid down, the following table would represent an adequate balance of evaporation and condensation with the appropriate degrees of elasticity between the points:

Height. Feet.	Sensible Temp.	Constituent Temp. of Vapour.	Elasticity.	State of Atmosphere.	Force of Evaporation.
0	80°	67.9°	.673	Clear.	327
5,000	64.4	[*]64.4	*.606	Cloudy.	467
10,000	48.4	19.0	.124	Clear.	
15,000	31.4	16.0	.112	do.	
20,000	12.8	[*]12.8	*.100	Cloudy.	80
25,000	−7.6	−20.7	.027	Clear.	
30,000	−30.7	[*]−30.7	*.020	Hazy.	

[*] are asteriaks added in the 1845 Ed.

The last column gives the relative force of evaporation at the different points, supposing the total effect, if unopposed and sudden, to be 1000, and the same numbers will represent the comparative amount of precipitation at the several intervals of condensation, or the relative densities of the three clouds. In this manner the struggle between the elasticity of the stream [corrected to steam in 1845 Ed.] and the condensing power of the cold is divided and moderated, and the whole process becomes so gentle as quietly to restore the balance of force and temperature, provided the counteracting cause be not of a permanent nature. The moisture falling gradually back into the excess of heat below is converted into vapour of higher force, which pressing more upon the inferior strata proportionably raises their densities. From (*Page* 64) these considerations it would appear that, in any single column considered by itself, clouds of greater or less densities, and evaporation of greater or less force must be the consequence of a temperature decreasing in a more rapid progression than is due to the law of aqueous vapour. While the atmosphere is in the state represented in the last table, let us now contemplate the effects of a general reduction of sensible temperature upon the constituent temperature and the different points of precipitation. We will suppose the fall to take place gradually, and to amount to 18°. In the first place, the elastic force upon the surface will be diminished, but will approach the point of precipitation within 3°. A plane of condensation will be established between the surface and the height of 5000 feet. So likewise the vapour from 9000 to 14,000 feet will not be disturbed, but the second plane of condensation will descend from 18,500 feet to an intermediate position between that elevation and 14,000 feet. The shifting of these planes would not be sensible at the surface for the light precipitations which would

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atmosphere is thus produced, heavier air presses in and flows as a wind from distant parts, not only over the ocean, but also sometimes over the low lands of continents, such as those of Asia and Europe. There are other winds which blow from dry to moist regions. In the northern portions of America, particularly during the winter, the air generally flows from the north, from one part that is comparatively dry and heavy to another part which has been rendered light by condensation of vapour brought by the tropical wind from the Atlantic Ocean to the Gulf of Mexico. The great mass of air, therefore, that passes over this continent in the winter flows southward to the Gulf of Mexico, in the neighbourhood of which, and against elevated land, the vapour that is at the same time brought from the tropical Atlantic is largely condensed. A part only of (*Page* 159) the vapour of the tropical seas passes into the Gulf of Mexico, as large portions of it turn northward over the Atlantic as well as over the Pacific Oceans, which portions are condensed on the western coasts of America and Europe. But the air which contained the vapour does not, after that vapour has been condensed, return to the tropics over the same two oceans, as in neither of them do north winds prevail. The moist south-west winds of the Atlantic, after being deprived of a large part of their vapour by cold, return in a dry state over the low lands of the continent; while the north-west winds of the northern part of the Pacific, after furnishing the rains of W. America, pass over Russian America and Behring Strait towards the Arctic Ocean, and return over the low lands of the central part of America as dry winds. Both of these land winds are dry, because they have been deprived of much of their vapour among mountains by cold; and they afterwards pass from colder to warmer latitudes, which renders them more capable of taking up moisture, and they press and flow towards their termini because there vapour has been brought from other parts by other winds to be condensed and to create a comparative vacuum in the atmosphere. Being in the northern hemisphere, these winds, with their peculiarities, are known to European meteorologists, but these meteorologists do not admit that the prime disturbing cause is the condensation of the vapour producing a vacuum in certain localities within the tropics. In the southern hemisphere we have facts of a similar character which are not equally well known. In that part of the world, as in the north, dry winds blow from cold to warm latitudes; and they also, as in the north, terminate in localities where a partial vacuum in the atmosphere has been created by condensation of vapour which has been brought from other parts. And thus we find that in both hemispheres cold and dry winds blow—not generally towards the equator as N.E. and S.E. winds, as is commonly assumed, but directly towards local areas of condensation of vapour, which are always found to be elevated land, against which, at the same time, warm and moist winds also blow. In the southern hemisphere there are not such broad continents as there are in the northern, yet the same flow of air over land rather than over water, (*Page* 160) from cool to warm latitudes, is observable in the former as in the latter. But there is ample breadth of ocean in the southern hemisphere, over which a cold aërial current might pass from the Antarctic Ocean to the tropics, and thus restore the equilibrium of pressure in a disturbed atmosphere in the way indicated in the Hadleian theory of winds, if the causes recognised in that theory were those which are really in operation. Over the whole Southern Ocean no palpable polar wind is to be found blowing to the tropics, such winds being confined to the comparatively small portions of land which exist in that hemisphere. Four separate winds in the southern hemisphere may be traced blowing from the south in a way that makes them correspond with the dry northern winds in the northern hemisphere; namely, two in America, one in Africa, and one in Australia. The first of these that may be noticed is the wind that blows along the low land of the western coast of S. America. It is first found about Valparaiso, say in lat. 33°, blowing moderately, but it increases in strength as it proceeds towards the equator, until it reaches the province of Guayaquil, a place which may be described as being in the most southern part of a very rainy district, included between 5° S. and 8° N.,

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into which vapour is brought from the heated surface of the Bay of Panama, extending westward into the Pacific Ocean, and the Mexican and Californian Seas. Now, if an atmospheric current is made to flow from the polar to the equatorial regions in the way alleged in the Hadleian theory of winds, why have we not a S.E. wind blowing over the whole Southern Ocean between America and New Zealand, instead of the limited Peruvian wind over a narrow strip of land? In this wide range of open sea a west wind of a decided character blows across the part south of lat. 38°, and nearer to the equator a broad strip of calm occurs until the eastern trade-winds of the S. Pacific is reached; but over the whole of this extensive ocean no such S.E. wind is found blowing from the polar towards the equatorial regions as would certainly blow there if the Hadleian theory were true. The second dry American south wind is found (*Page* 161) on the east side of the Andes. It commences near the Straits of Magellan, and passes over E. Patagonia and the pampas of Buenos Ayres, approaching the great region of condensation that exists on the east side of the Andes; a region where the atmosphere must be made light by the large amount of vapour coming from the tropical Atlantic that is known to be there condensed, forming a partial vacuum, into which the cool and dry air passes from the line of country that has been pointed out. The (*Page* 162) dry air itself does not take sufficient vapour to produce a considerable vacuum at the place of its termination; nor does much rain fall, excepting among the Andes, to the south of say 25° lat. The vacuum that gives birth to this southern wind is therefore evidently produced by condensation of vapour, which is mostly brought up the broad valley of the Amazon from the tropical Atlantic Ocean, and that condensation, by producing an atmospheric vacuum, must be considered the prime disturber of the aërial equilibrium in this part of the world, which the influx from the south tends to restore. In like manner, Hopkins gives details respecting Africa, from which he infers that in the central part of Africa there exists a region of condensation (*Page* 165) of aqueous vapour, which vapour is brought principally from the Gulf of Guinea and condensed among mountains, producing a vacuum towards which the air from more southern parts presses and flows as a southern wind; and being carried into the vacuum, and ascending to a sufficient height, its own portion is cooled and condensed, increasing the vacuum and augmenting the rainfall in the area. As regards Australia little is known. There are extensive dry regions, but there do not appear to (*Page* 166) be any great areas of condensation. In the East Indian Archipelago there is an area of condensation of aqueous vapour probably equal in magnitude to any other on the surface of the earth. Currents of air are known to set in towards this area, and probably the dry south wind of Australia is one of those indraughts which only produces rain on the higher lands. It may be observed that some of the most southern lands in the south hemisphere have considerable rainfall where the winds just strike them. This (*Page* 167) must cause them to be drier in the regions north of them. In July 1853 Mr. L. Blodget described a dry wind which terminated in a rainless district. It (*Page* 168) blows from the Gulf of Mexico inland. But is it exhausted in a rainless district? Rather, is it not that it blows over the dry region and reaches to the sources of the Red River, Mississippi River, and other large streams. If heavy rain falls in a locality towards which a dry wind blows, we may safely infer that it blows towards a rain-made atmospheric vacuum? Should the part described by Mr. Blodget prove to be a district made rainless in summer by condensation in the country to the north of it, it will prove a striking instance of the power of vapour to cause a wind to blow towards the place where its condensation is occurring. The vacuum about the sources of the Missouri would be proved to be sufficient to draw air even from the Mexican Gulf, in opposition to the powerful influences that exist in other parts around that Gulf, and also to make the air pass northward over the rainless district described. For the sake (*Page* 170) of clearness we have confined our attention to the more general and permanent winds. The discussion of the smaller and temporary disturbances would have

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made the matter obscure. The general laws which govern the changes in the atmo- (*Page* 171) sphere are usually not complicated. Under the operation of these laws certain localities have great influence in producing motion in the atmosphere, and creating the general currents in it which determine its circulation. Over the ocean evaporation is continually taking up vapour, which by its elastic force expands and diffuses itself through the gases; and the amount of heat thus taken up to be afterwards used in expanding the gases in particular localities is enormous. Through a difference in the laws of cooling by expansion of vapour and gases, this heat would in all parts be given out at certain heights, when the cold of the gases condensed the vapour, and rain would fall with considerable uniformity. But as there are certain elevated lands distributed over the surface of the earth, against these the vapour is largely condensed, and towards those lands atmospheric currents flow, or must flow, producing continuous aërial movements and ascents in the area of condensation. The ascents cause a boiling up and overflowing of large masses of the atmosphere in the higher regions, where they diffuse themselves. These localities of condensation may here be given in their order of importance. The first is found on the east side of the Andes, where the rivers La Plata, Amazon, and Orinoco have their sources. The second is in and about the Himalaya Mountains. The great Asiatic Archipelago is the third. The tropical African mountains may be next, giving rise to the Nile and Congo. Then follow the Rocky Mountains of North America, the mountains of Chili, West Patagonia, and Terra del Fuego, the Alps and (*Page* 172) mountains of central Europe, the Scandinavian and the British mountains. Over all these mountainous countries aqueous vapour is largely condensed, and the atmosphere is made to boil up and overflow each place in proportion to the amount of vapour brought for condensation, and the height to which the vertical current ascends. The air discharged above in due time comes down to the surface, and thus a general circulation of the atmosphere is established. There is no evidence that dry air ascends over hot plains to any considerable height. The higher currents in the atmosphere probably flow from the areas of condensation to the regions where the dry winds commence at (*Page* 173) the surface, deriving their supply from descending currents.

[The controlling influence of evaporation and of the condensation of aqueous vapour in producing the disturbances in the equilibrium which generate winds was fully and clearly ênunciated by Daniell in 1823. The remarks made by Hopkins find a place on account of its giving his conception, or rather what may be inferred to be his conception, of the distribution and circulation of aqueous vapour. As it was difficult to give this without bringing in his more general ideas, no attempt has been made to separate them.]

Parish, Alfred. *Journ. Roy. Geog. Soc.*, vol. xxvi. (1856.) (*rv.*)

(*Page* 156.) In some parts of the equatorial regions the southern cyclone seems to rise from the surface at that point which represents the S.W. or S.S.W. winds, and the northern one at that representing the N.W. or N.N.W. winds; while in other parts, especially towards large continents, the due westerly winds appear to extend over many degrees of longitude. May this not be from local influences or differences in the humidity of the atmosphere causing a variation in the angle at which the surface strikes the surface diagonally.

1857.

Grant, W. C. *Journ. Roy. Geog. Soc.*, vol. xxvii. (1857.) (*rvp.*)

(*Page* 275.) In Vancouver Island a parching heat prevails from March to October, which dries up all the small streams. In the commencement of autumn dense fogs prevail, enveloping everything in obscurity.

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Osborn, Sherard. *Journ. Roy. Geog. Soc.*, vol. xxvii. (1857.) (*rvp.*)

(*Page* 144.) In the Gulf of Azov, after the end of August, short fierce squalls set in from the northward, varied with S.E. winds, which are preceded by dense fogs. These true S.E. winds are sometimes turned into easterly winds by the land, but their character, and the fogs which accompany them, distinguish them clearly from the hot summer wind. Great and sudden variations of temperature are now experienced, which fully account for the squalls from the northward and the dense sudden fogs from the south. These squalls give plenty of indication by a dense body of black clouds in the quarter from whence they may be expected.

1858.

Hopkins, J. (*B.* 1858, 1.)

[Nothing appertaining to these notes which is not to be found in his earlier paper in 1856.]

1859.

English Cyclopædia. (*B.* 1859, 1.)

(*Col.* 973.) In the equatorial zone the air is clear till about two hours before noon, when the clouds begin to appear until rain sets in at noon. Towards evening the clouds disappear, and the sun sets in a clear blue sky. No rain falls in the night. (*Col.* 974.) During the rainy season the rains frequently flood the low and level country a foot deep with water, so that the atmosphere of such tracts is continually loaded with vapour and exhalations, which render the stars invisible at night, and are doubtless a principal cause of the unhealthiness of these countries.

English Cyclopædia. (*B.* 1859, 2.)

(*Col.* 984.) From what has been observed at Teneriffe, it seems that in all climates, the rainless tracts excepted, a considerable stratum of clouds commonly exists over the land, the inferior surface of which is at a height varying from 2500 to 3000 feet, whatever of cloud there may or may not be above or below that altitude.

Journ. Roy. Geog. Soc., vol. xxix. (1859.) (*rv.*)

[Nothing for these notes.]

1860.

English Cyclopædia. (*B.* 1860, 1.)

(Vol. iii. *Col.* 498.) The vapour plane where clouds form represents an area where the dew-point prevails and the cloud corresponds to the dew. A. de Candolle and A. (Vol. iv., *Col.* 150.) Henfrey infer from the distribution of the species that ligneous plants established themselves in northern and temperate countries when the climate must have been more humid and more cloudy than at present. [The greater dryness at present may be due to the destruction of forests, which formerly seem to have been (*Col.* 158) general.] If all the forests on the globe were destroyed the atmosphere (*Col.* 740) would be exceedingly deficient in moisture. The leaves of plants which thrive in the dry air of the tropics are large and succulent. In the tropics generally the degree of dryness of the air seldom exceeds 10° of Daniell's hygrometer. In tropical countries the air is saturated with vapour during the night, or at least it is

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(*Col.* 752) seldom otherwise in the open air. As a general law it may be stated that the humidity [=high dew-point] of the atmosphere decreases from the surface of the earth upwards. The great dryness [= low dew-point] of the atmosphere near the summits of mountains has been frequently remarked by travellers. Biot observes that the fall of the mercury is a more certain sign of rain than is its rise of fine weather, since the ascent of the clouds is not necessarily accompanied by their dispersion. From the agitation produced by wind the upper regions of the atmosphere are often charged (*Col.* 794) with aqueous vapour. Hygrometry is that part of natural philosophy which (Vol. v., *Col.* 272) relates to the humidity particularly of the atmosphere. Early in a thunder-storm there is some alteration of temperature as well as considerable barometric (*Col.* 273) and hygrometric changes. Evaporation increases the electrical condition of the (*Col.* 708) air. [Since the Bibliography was published the statements in this column (*Col.* 709) have been entered from earlier publications.] Soon after sunrise in fair weather, the vapour near the earth having been precipitated by the night cold in the form of dew, and the sloping rays of the sun having little power to raise more vapour, the air is almost perfectly transparent, and every object has a clearness and sharpness of outline which it never has at any other time of the day. On our rivers and seas towards the end of summer, throughout the autumn, and the beginning of spring, the frequency and amount of mists are remarkable.

Grey, Earl de. (*B.* 1860, 2.)

(*Page* cxlv.) The prevalence of moist air, much or little cloud, can be predicated approximately of any place, although no observations have been made there. Cold dry (*Page* cxlvii.) air from a polar direction is heavier than warm moist air blowing from (*Page* cxlviii.) tropical or equatorial regions. Evaporation, rarefaction, or condensation of vapour in air, reduces its specific gravity, the two former by expanding bulk and rendering it lighter through mechanical diminution of quantity by falling to the earth in rain, &c.

1861.

Eaton, H. S. *Proc. Brit. Meteorol. Soc.*, No. 1. Nov. 1861. (*rv.*)

(*Page* 12.) Various theories have been advanced as to the cause of the increase of rain in hilly districts. One (the most commonly received) is, that a current of air saturated with vapour, on coming in contact with the cold hills, has its vapour condensed, which falls as rain. This cannot, however, be so; if it were, we should invariably have rain when in the winter months a warm and saturated S.W. wind succeeded a frost as long as the ground remained unthawed, instead of a thin surface-fog, as usually obtains. In the autumn, too, after clear nights the dew-point temperature is often higher than that of the ground and pavement, under which circumstances we find the vapour condensed on the surface, which appears wet in consequence. The true explanation is, that whereas the temperature of the air decreases $1\frac{1}{2}^\circ$ F. for every 100 yards of ascent, the dew-point only decreases $\frac{1}{2}^\circ$; if then a stratum of air, in which the complement of the dew-point is 5°, be raised through a vertical space of 1200 feet, (*Page* 13) the vapour which it contains will begin to condense into cloud. Now, let us imagine a south-westerly surface wind to be setting in from the Atlantic, at a temperature of 52° and a dew-point of 48°, as is frequently the case in autumn and early winter [in Devonshire]. On reaching the land a ripple is produced, and on crossing the Dartmoor hills the whole stratum is lifted up about 1700 feet. In rising through this extent the air expands and cools; at a height of 975 feet the cold produced by expansion will begin to condense the vapour into cloud, and all the hills above this elevation will be capped with fog, the temperature at this point being 48°; in a further

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ascent the latent heat evolved by the process of condensation will prevent the air cooling as fast as it did, to the extent of nearly three-fourths the amount; so that at 1700 feet the temperature will not be lower than 47·3°; under favourable circumstances, however, rain will ensue. On passing the hills the mist sinks, becomes warmed under greater pressure, and evaporates.

English Cyclopædia. (*B.* 1861, 3.)

(*Col.* 928.) In general the lowest stratum of air above the earth contains the greatest quantity of aqueous vapour, and hence it might be expected that more rain should fall on low level plains than in elevated countries. The contrary is the fact, and this may be accounted for by the variety of currents among mountains and by clouds descending frequently on the summits of hills without descending to the plains.

(*B.* 1861, 6.) (*ra.*)

(*Page* 573.) During the eclipse of the sun, July 18, 1860, there was a marked increase of humidity at the various places where the eclipse was observed.

Journ. Roy. Geog. Soc., vol. xxxi. (1861.) (*rvp.*)

[Nothing for these notes.]

1862.

Bell, C. N. *Journ. Roy. Geog. Soc.*, vol. xxxii. (1862.) (*rvp.*)

(*Page* 247.) In the Mosquito country, towards the end of May, every day, towards the afternoon, the clouds which are brought over from the sea are piled in a dark bank (*Page* 248) to the westward. This gathering of clouds is occasioned by the land breeze, which begins to be prevalent now during the night.

Bellingham, W. (*B.* 1862, 2.)

(*Page* 110.) The recurrence of phenomena indicating the existence of a tide or belt of vapoury clouds, traversing the atmosphere alternately from pole to pole at regular intervals of 40 days, has for some years past attracted the author's attention. This tide, which would pass and repass the latitude of Peru at intervals of 20 days, may be connected with the Peruvian period of 20 days, at intermediate regions between the equator and the poles would return at longer or shorter intervals according to the (*Page* 111) latitude of the place. For example, from the time it passes northwards over London to its return to the same latitude would be about 10 days, if it moved at an estimated rate of 20 miles in an hour; its next return after going south would be in about 30 days. Owing to many counteracting influences it would be difficult to predict the effects of the tides. Under certain conditions of the atmosphere, however, it would probably produce storms and rain. Though the belt of vapour is supposed to be continuous, it is probable that some parts of it would be considerably in advance of others in those regions where least resistance is offered to its progress. The supposed periodic tide of 40 days would sometimes combine with the lunar atmospheric tide of about 27 days, and at other times be in opposition to it. The theory is founded upon observations in the latitude of London.

FitzRoy, R. *Journ. Roy. Geog. Soc.*, vol. xxxii. (1862.) (*rvp.*)

(*Page* cxxxii.) Air currents retain their characteristics for a considerable time. Thus we may have by deflection, for short times only, cold dry winds from the S.W., or warm

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(*Page* cxxxv) moist winds from the north. With polar currents of air, clouds have a hard oily appearance; with the tropical currents they have a soft watery aspect, without hard edges or outlines.

Glaisher, James. *Proc. Brit. Meteor. Soc.*, vol. i. (No. 5, published Nov. 19, 1862.)

[Plate vii. He shows the balloon track rising to 23,500 feet, and cirri above, between five and six miles, the highest at over 31,000 feet. This was during the ascent from Wolverhampton.] The observations made during his balloon ascents (*Page* 259) [which are detailed in the paper] indicated that the temperature of the dew-point decreases on leaving the earth less rapidly than the temperature of the air, so that the difference becomes less and less till the vapour plane is reached, when they are usually together, and always most nearly approach each other (this elevation was about 5000 feet high); that immediately after leaving the upper surface of the cloud the dew-point decreased more rapidly than the temperature, and in the extreme high stations the difference between these two temperatures is wonderfully great, indicating an extraordinary degree of dryness and an almost entire absence of aqueous vapour. Under these circumstances the presence of cirrus clouds far above the dry region (*Page* 260) is very remarkable; on all occasions when seen they appeared still as far above as when viewed from the earth. Of what can they be composed?

Gregory, F. T. *Journ. Roy. Geog. Soc.*, vol. xxxii. (1862.) (*rep.*)

(*Page* 428) N.W. Australia, 1861.—Latterly the wind was alternately S.E. in the morning and N.W. or westerly in the afternoon, the sky frequently becoming overcast. [By latterly is meant getting on for October.] The rainy season, from the observations of previous explorers, is from about the beginning of November on to March.

Herschel, Sir John F. W. *Meteorology*, 2nd Ed., 1862.

(*Page* 2.) Supposing there were no latent communication or transfer between the columns of air incumbent on adjacent parts of the earth's surface, the totality of atmospheric and climatic change in any given locality would be limited to periodical and perfectly regular fluctuations of temperature, and to the alternate generation and condensation of vapour, equally periodic and regular, immediately consequent on such fluctuations, over those parts of the surface occupied by water. No rain would ever fall or cloud form over any part of the land, which would be perfectly arid. Air (*Page* 17) contains on an average 0·45 per cent. of aqueous vapour. When aqueous (*Page* 25) vapour ascends by its levity it drags air up with it—not by heating it, but by mechanical impulse; and thus we see that the mere fact of a circulation of air in the atmosphere, in so far as that circulation is due to the generation and condensation of vapour, or even to the downward mechanical impulse of the fall of rain or snow, must of necessity cause a deficiency of sensible heat in the higher as compared with the (*Page* 48) lower regions. Mr. Glaisher's observations clearly show that the higher the cloud the greater is the radiation upward. Thus on nights uniformly and totally cloudy, the mean heights of the clouds being respectively 1700, 2800 and 3700 feet (which his peculiar situation enabled him to ascertain), the depressions were found to (*Page* 49) average 1·6°, 2·5°, 3·9°, clearly indicating the lower temperature of the higher clouds. Water freely exposed to the air evaporates at all temperatures, even when in (*Page* 50) the state of snow or ice; *cæteris paribus*, the amount of water evaporated is proportionate to the surface exposed to air. It is much greater, therefore, from rough and porous solid substances kept wetted (as for instance from moist soil or from vegetation wetted by rain) than from the surface of water itself, and from the latter (*Page* 51) when agitated by winds or lashed into spray than when tranquil. Vapour,

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introduced into the air, acts as a moving power in two ways—first, by a simple addition of volume; second, by its less specific gravity, in consequence of which as soon as it (*Page* 52) is generated it tends to rise in the air by its buoyancy, and in so doing carries up much of the air with which it is intermixed, disengaging itself no doubt from it in its upward progress to become entangled with fresh particles, which again it raises upward to abandon them for others. In this way not only is its upward diffusion far more rapid than its horizontal, but in its struggle upwards it tends to produce an ascensional movement in the air itself, and thus to act as a powerful agent in the (*Page* 53) production of wind. In every case the condensation of vapour is accompanied with a mitigation of cold at the point where it actually takes place. It is clear, moreover, that the generation of vapour under any extensive region more rapidly than it is carried off by diffusion or otherwise, must be attended with an increase of barometric pressure, since the total weight of the atmosphere vertically over any region must be supported by the total area of surface, and equally so that its condensation, provided that the condensed water be abstracted from the atmosphere, must lead to a diminution of pressure. The contrary will happen if the vapour generated be carried off as fast as produced by such a general upheaving of the aërial strata over any region as shall subvert their equilibrium and cause them to overflow upwards and laterally. In such a case, since air also will be carried off bodily from the region and be replaced by vapour, the mean specific gravity of the whole aërial column and its total weight will be diminished and the barometric pressure lowered. This takes place on a most extensive scale over the intertropical seas. The temperature of the surface water in (*Page* 54) them is habitually very elevated (from 78° at the tropics to 83° at the equator) and varies very little. A steady and copious evaporation is therefore continually going on. Vapour, carrying with it air, is constantly thrown up beyond the levels of equilibrium, where it flows over and spreads itself out over the upper regions of higher latitudes. The immediate consequence is a habitual deficiency of barometric pressure at the sea level on the equatorial as compared with that on the extratropical seas. In a voyage to the Cape of Good Hope in 1833–4 the writer of these papers found the decrease from the tropics to the equator on either side to amount to 0·24 in. Schouw and Humboldt had previously noticed this fact. Air is less dilated by heat than by the (*Page* 55) introduction of vapour, but in both cases a local relief of pressure is equally produced. Winds subvert the solar climate and produce its real climate directly by transferring heat and aqueous vapour with its latent heat from one region to another; (*Page* 81) and indirectly by means of the oceanic currents they cause. The winds act indirectly as distributors of heat and moisture by producing currents in the ocean. [Apparently he attributes the great ocean currents mainly to wind influence.] The most (*Page* 84) immediate, though assuredly not the most obvious result of this state of things [that is, of unequal distribution of temperature and system of winds] is the habitual hygrometric or relative dryness of the higher regions in clear weather. This is shown by very demonstrative facts. Thus Deluc remarked that the head of his walking-stick always fell off in high mountain ascents from the shrinking of the wood. Every (Essays by Sir J. Herschel, 1835) act of precipitation withdraws from the total mass of air some portion of its entire amount of vapour. As such precipitations are constantly going on in some place or other, the atmosphere as a mass, though incumbent on a wet and evaporating surface, is necessarily always deficient in moisture; and for the very same reason every superior stratum is relatively deficient in comparison with that immediately beneath it, from which its supply is derived. In point of ultimate causation, then, there is a constant drain on the aqueous contents of the atmosphere arising from changes of temperature. This drain extends to all its strata, but while the (*Page* 85) lower renew their losses from a surface hygrometrically wet, the upper draw their supply from sources more and more deficient in moisture. What the equatorial depression of the barometer at the sea level, then, is to the system of winds, such is the

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habitual hygrometric dryness of the air above the clouds to that of rain—at once an indication of a process in progress and an efficient agent in continuing it. Wherever such relative dryness exists, vapour, by its own expansive nisus, is in the act of transfer in an invisible state from one atmospheric region to another, and the rapidity of that transfer is proportional, *cæteris paribus*, to the degree of dryness. This by no means supposes a universally prevalent deficiency of vaporous tension. Complete saturation must exist at the points of evaporation and deposition, but at intermediate ones any amount of irregularity may prevail according to local circumstances. The method now (*Page* 86) adopted in preference to all others [for ascertaining the amount of vapour in the air], or the most simple and convenient in practice, and leading to results which a very severe examination has proved to be quite satisfactory, is the simultaneous observation of the wet and dry thermometers. The formula of reduction, as it results from Dr. Apjohn's investigations, is as follows:—Let t, t' be the respective readings of the wet and dry thermometers (in degrees Fahr.), h the barometric pressure in inches, f the elastic force of the saturated vapour at the temperature t, and F its elastic force at the dew-point. Then will

$$F = f \cdot \frac{t'-t}{80} \cdot \frac{h}{30}; \quad \ldots\ldots (a)$$

Or,

$$F = f \cdot \frac{t'-t}{96} \cdot \frac{h}{30}; \quad \ldots\ldots (b)$$

the equation (a) or (b) being used according as t, the reading of the wet thermometer, is above or below 32°; f is found from a table; and F being calculated from the above expression, the dew-point may be had from the same table used reversely; F known, the weight of water per cubic foot is found by multiplying the weight of a cubic foot of dry air at 30 in. (563·214 grains) by the specific gravity of steam for elasticity F; *i.e.* by $F \times 0{\cdot}6235$. Copious tables for facilitating the whole process have been published by Mr. Glaisher (1847). Although Hutton's theory of solution is exploded, its language, being convenient, is retained. When the air in contact with a radiating surface has (*Page* 91) been reduced in temperature to the dew-point, it remains saturated, and at the same time colder than that above it. On level ground, in a calm, little or no mixture of the upper and lower air will occur; but on a slope the cold air will run downwards, and mixing with the air below, if sufficiently near to saturation, will depress the mean temperature of the mixture below its resultant dew-point, and produce fog. If the low ground be occupied by water or marsh, as the air in it is sure to be saturated, copious precipitation will necessarily result. If dry, the mist produced will (*Page* 92) be less copious, and may not even take place at all. In the Weald of Kent, a district abounding in grassy slopes and branching valleys, in the calm clear nights which are there so frequent, beautiful instances of radiation fogs are of perpetual occurrence. Immediately after sunset dew commences; streams of cold air set downwards, following the line of shortest descent, their course being marked with mist, thin and filmy at first, but acquiring density in its downward progress, and by degrees filling the valleys with fog, which in the morning before sunrise presents exactly the aspect of a winding lake or river of water, whose surface, perfectly even and horizontal, runs a sharply-defined line round every promontory, and into every retreating nook. A (*Page* 93) radiating fog, once formed, tends to its own increase by radiating off heat from its own particles. When the warm current in the open ocean encounters a shoal, the lower water (of inferior temperature) is thrown up to the surface. The surface water, therefore, on the shoal is colder than that of the surrounding ocean, and the atmospheres (saturated at the respective temperatures) mingling, produce those fogs which are observed to be prevalent in such localities. The fogs of Newfoundland are a remarkable instance in point. Fogs, too, are produced in the neighbourhood of icebergs on a similar principle. The Arve, in its descent from Chamouni, occasionally presents the appearance

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of warm water throwing up steam (though in fact many degrees colder than the air), from the mixture of the cold air above it with the saturated warmer air of the valley through which it flows. (Obs. August, 1821.)

Barometric Fogs.—The temperature of a mass of air may be lowered beneath the dew-point by the simple effect of its own expansion. This may take place in two ways: (*Page* 94) viz., first, by a rapid and considerable relief of barometric pressure from above; or secondly, by its own ascent into a higher region of the atmosphere. The first case takes place when the trough of an atmospheric wave passes rapidly over the place of observation. The fog so produced comes on for the most part suddenly and without any obvious cause. It is not rolled in from a distance by wind, nor does a moderate wind dissipate it. It is not confined to the surface of the ground, but extends at once to great altitudes. It does not resolve itself into rain, but disappears, when the atmospheric equilibrium is restored by the recondensation of the air and the reappearance of its sensible heat. Such fogs are very common, and are precisely analogous to the cloud produced in the receiver of an air-pump by a rapid partial expansion of the air. They want a name, and that of "barometric fogs" seems not inappropriate. There is a fog of not very frequent occurrence in our [= British] climate which comes on gradually in a perfectly calm state of the air, without any sudden or considerable diminution of barometric pressure, and which evidently arises from a gradual increase of humidity in the air, at length attaining the dew-point. Such fogs would seem not unnaturally to result from the quiet lateral diffusion of vapour as a gas from some neighbouring or slowly approaching mass of vapour-loaded air, in anticipation of its bodily arrival as a moist or rainy S.W. wind. To such a fog the epithet of "diffusional" may not (*Page* 95) improperly be applied. When a body of vapour is generated from any warm evaporating surface it ascends by its relative levity, losing sensible heat as well by its own expansion as by its bodily transfer into and intermixture with colder air. When clouds form in a calm state of the air, and the evaporating surface is limited in extent or irregularly distributed in patches (as over marshy ground, rivers, lakes, &c.), or if any other cause dispose the vapour to rise in columnar bodies of greater or less extent, the summits of these clouds are marked by protuberant masses or piles of clouds, with generally rounded outlines, which appear to repose on flat bases, indicating the vapour plane. To such clouds Howard gave the name of "cumulus." They abound in the calm latitudes of the equatorial seas, and form a distinguishing (*Page* 96) feature in the meteorology of that region. That the self-expansion of the ascending air is sufficient to cause precipitation of some of its vapour when abundant, is rendered matter of ocular demonstration in that very striking phenomenon so common at the Cape of Good Hope, where the S. or S.E. wind, which sweeps over the Southern Ocean, impinging on the long range of rocks which terminates in the Table Mountain, is thrown up by them, makes a clear sweep over the flat table-land (about 3850 feet high), and thence plunges down with the violence of a cataract, clinging close to the mural precipices that form a kind of background to Cape Town, which it fills with dust and vapour. A perfectly cloudless sky prevails meanwhile over the town, the sea, and the level country, but the mountain is covered with a dense white cloud, reaching to no great height above its summit, and quite level, which, though evidently swept along by the wind and hurried furiously over the edge of the precipice, dissolves, and completely disappears on a definite level, suggesting the idea (whence it derives its name) of a "table-cloth." Occasionally, when the wind is very violent, a ripple is (*Page* 97) formed in the aërial current, which, by a sort of rebound in the hollow of the amphitheatre in which Cape Town stands, is again thrown up just over the edge of the sea, vertically over the jetty, where we have stood for hours watching a small white patch of cloud in the zenith, a few acres in extent, in violent internal agitation (from the hurricane of wind blowing through it), yet immovable, as if fixed by some spell, the material ever changing, the form and aspect unvarying. [See Notes, 1823, Daniell,

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p. 123]. The form and aspects of clouds are very indicative of the circumstances under which they are in the act of forming or dissipating. The form of the cumulus clearly (*Page* 98) indicates the act of self-dissipation in invisible vapour into the upper relatively dry air. Stratus may be considered as intermediate between cloud and fog, being chiefly formed at night, and under the influence of radiation either from the surface of a ground fog or from impurities floating in the air itself. The latter is remarkably the case in great cities in which coal is chiefly consumed as fuel, and gives rise to those dense, yellow, suffocating fogs which infest London in the winter months. It would seem that each particle of soot, acting as an insulated radiant, collects dew on itself, and sinks down rapidly as a heavy body. Stratus is also formed very suddenly on a higher level, when in a clear calm night the general temperature of the air sinks by radiation or by diminution of atmospheric pressure till at some definite altitude above the surface the dew-point is attained. Thus on the night of April 19, 1827, the (*Page* 99) sky up to 16 h. 16 m. sid. time being perfectly cloudless, and not a breath of wind stirring, stratus at a high level commenced in the eastern horizon, and in eight minutes had extended to the western, obscuring the whole sky, the calm remaining unbroken. In this case the velocity of propagation of the edge of the cloud from E. to W., or following the sun, could not have been less than 300 miles per hour. The filamentous structure of the cirrus clouds, occupying the highest regions of the atmosphere, clearly indicates them as either in the act of originating from the union of aërial currents running parallel to each other, or as the residues of dissolving cloud drawn out into fibres by the wind. The cirrus is said to be often a precursor of windy (*Page* 100) weather. The cirro-cumulus clouds usually float at great elevations, and often appear as a loftier stratum through the intervals of lower clouds. They are frequent in summer, and attendant on dry and warm weather. The cirro-stratus appears to result from the subsidence of the fibres of cirrus to a horizontal position, at the same time approaching laterally. It often precedes wind and rain. The cumulo-stratus would seem to be the modification of cumulus formed when the columns of rising vapour which go to form it arrive in an upper atmosphere not sufficiently dry to round off its summits by rapid evaporation, thus allowing them to spread horizontally and form flat-topped, mushroom-shaped masses, the upper parts of which are often curled by the wind of an upper current into cirrous wisps, or cleanly cut off by a horizontal plane, forming an "anvil-shaped cloud" with a lateral projection, generally considered as a precursor of wind below. The tendency of cumulo-stratus is to spread, overcast the sky, and settle down into the nimbus, and finally to fall into rain. When two strata (*Page* 101) of clouds on different levels tend to unite, it is evident that the intermediate region must be nearly or quite in a state of hygrometric saturation. The cloud then forms confusedly and in irregular masses through the whole region, and finally resolves itself into heavy rain. When cloud is present the sun's rays are of course prevented from reaching the earth directly, and their heat is diffused through the general atmosphere, thus softening and mitigating their ardour. When the sun shines on a cloud which absorbs its heat, the cloud itself is necessarily partially evaporated, and the vapour by its levity tends to produce an upward current, and thus to counteract the effect of gravity on the globules of which it consists. A globule of water 1-4600ths in. in diameter, in air of five-sixths of the density on the surface, or at the height of about 5000 feet, would have its gravity counteracted by resistance with a velocity of descent of one foot per second (supposing no friction and no drag), and even if the terminal velocity were reduced to half that quantity by these causes, would still require some such upward action to enable it to maintain its level, a circumstance which sufficiently accounts for the lower level generally observed of cloud during the night. It is more than probable that when it is not actually raining a cloud is always in process of generation from below and dissolution from above, and that the moment this process ceases, rain in the form of "mizzle" commences. In a word, a cloud in general would seem to be merely

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(*Page* 102) the visible form of an aërial space in which certain processes are at the moment in equilibrio, and all the particles in a state of upward movement. The (*Page* 104) increased quantity of rain measured by the rain gauges nearest the ground is usually accounted for on the hypothesis that the cold rain-drop condenses moisture in falling through an atmosphere nearly or quite saturated. But this cause is insufficient, as rain falling from 12,000 feet, and bringing a temperature of 40° F. to 213 feet, would have its weight increased by $\frac{1}{15}$ only, or $\frac{1}{17}$ of the quantity to be accounted for. (*Page* 105) Visible cloud rests on the soil at low altitudes above the sea-level but rarely; and from such a cloud only would it seem possible that so large an accession of rain could arise. (*Note.*—These remarks were made in 1857. More recently, March 29, 1860, a paper was read by Mr. Baxendell to the Lit. and Phil. Soc. of Manchester on this subject. He arrives at the same conclusion as to the insufficiency of the mere condensation of vapour on the falling drops to account for the phenomenon in question, and concludes that it is impossible to account for it except by the admission of the existence of water not in the state of true vapour, but already deprived of its latent caloric—in the atmosphere—though not affecting its transparency, so that a shallow stratum of the lower and comparatively clear atmosphere may supply as much rain as a densely-clouded and much deeper stratum in the higher regions. Mr. Baxendell hesitates to admit that the water can be present in the actual state of water, on account of its invisibility. He adds a very remarkable fact recorded by Mr. Binney, who, in descending the shafts of deep coal mines, has observed that the drops of water which drip from the upper part of the shaft increase to an extraordinary size in their descent to the bottom). The (*Page* 106) greater part of the enormous evaporation of the equatorial seas is at once condensed, and discharged again in rain from the cumuli which marks its uprush into the higher and colder regions of the air, the rain being most continuous where the sun is most vertical, or in the region of calms. The trade winds themselves, coming from higher latitudes, are acquiring temperature and taking up moisture from the sea. The returning counter-currents having discharged their first overload of moisture, pursue their course aloft, free from cloud and relatively dry; and in the neutral interval between them and the opposite lower current, cloud is not generated or rain produced by the intermixture of the two, the upper portions of the trades not being saturated. The clouds which do occur in these winds belong not to their higher strata, but to (*Page* 107) a much inferior level, not exceeding 5000 or 6000 feet in altitude, while the medial line between the winds has nearly double that elevation. Such at least are the phenomena on Teneriffe, as seen by C. P. Smyth in August. Between the tropics the year is divided into a wet and dry season; the dry, when the sun is in the opposite hemisphere and the trade winds blow strong; the wet, when in the same, and approaching the zenith. In the neighbourhood of the equator, where the sun passes the zenith twice at several months' interval, there are two dry and two wet seasons. Beyond the tropics, where the anti-trade or returning current descends to the level of the earth's surface, and by degrees takes up the temperature of our milder latitudes, its vapour, held so far in abeyance, becomes available for the production of rain, unless inter-
Page 108) cepted by some mountain-barrier tossing up the stream, and prematurely precipitating its vapour. Where this obstacle does not exist, however, the rains are distributed in the extra-tropical regions with considerable indifference as to season; in some, indeed, a certain approach to a wet and dry season of the year prevails. Since, however, the deposit of water from the air must of necessity bear some rude proportion to the actual quantity *in transitu*, the amount of rain or snow which falls on any country must, on a general average, diminish as the latitude increases. The origin of (*Page* 126) aërial electricity has been traced with every appearance of probability to (*Page* 127) evaporation. Pouillet showed that electricity was developed only when chemical change attended the evaporation. The processes of vegetation in which water is abundantly separated from the other constituents of plants, and perhaps also other

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vegetable processes, are also sources of electricity. Thus we are led to look to the immense evaporation both from sea and land, and to the vital processes going on in the latter, as furnishing at least the chief supply of electricity in the air. Volcanic eruptions and conflagrations contribute their quota. The periodic fluctuations of the (*Page* 156) barometer are annual and diurnal. The consideration of the former will enable us to form a neater conception of the mode in which the latter arise. When it is summer in one hemisphere, it is winter in the other. Hence the air generally incumbent on the heated hemisphere is dilated, and expands both upwards and laterally, not only by its increased elasticity, but also by the increased production of vapour. It therefore not only encroaches on the other hemisphere by lateral extension, but, what is far more influential, flows over upon it. In order to perceive clearly the nature of the process, we must separate in idea the aqueous and aërial constituents of the portion of the air so transferred. The generation of the former goes on in the heated atmosphere, and replaces, in part at least, the loss in pressure arising from the transfer of air, while in the other the excess of vapour so introduced is constantly undergoing precipitation, and is thus constantly being withdrawn from the total mass, leaving behind it, however, to accumulate, the dry air which accompanied it. Thus, if we regard the total barometric pressure as subdivided into that of the dry air and of the aqueous vapour, and denote the former by P, the latter by V, we see that the dry pressure is diminished in the hot and increased in the cold hemisphere without any countervailing action, while P is in process of increase from below by evaporation and of diminution from above by overflow in the former, and *vice versâ* in the latter. If, then, the observed barometric pressure at every point in either hemisphere be analysed by calcu- (*Page* 157) lation into its two constituents, by taking account of the hygrometric state of the atmosphere, and subtracting from the total pressure, P × V, the portion due to the amount of vapour present, the remainder ought to exhibit, as a general result, an excess of dry pressure, P, in the winter hemisphere over that in the summer. So far as observation has hitherto gone, this result is perfectly corroborated, though, unfortunately, there are not yet accumulated sufficiently numerous and extensive series of observations in which the effects of the aqueous pressure can be duly separated from the dry. As examples, we shall select the series from the Indian stations, Calcutta, Benares, Seringapatam, and Poonah, calculated by Dove from the observations of Prinsep, Sparmann, and Col. Sykes, as compared with that at Apenrade from those of Neuber, and with the results obtained at the meteorological observatories of Prague, Toronto, and Hobart Town :—

Stations.	P, pressure of dry air. Max. in	Min. in	Diff. in.	V, pressure of vapour. Max. in	Min. in	Diff. in.
Calcutta	Jan.	July	1·019	Aug.	Jan.	·551
Benares	Dec.	July	1·244	July	Dec.	·645
Seringapatam	Jan.	June	·455	May	Jan.	·217
Poonah	Dec.	July	·760	July	Dec.	·435
Apenrade	Feb.	July	·450	July	Jan.	·346
Prague	Dec.	July	·383	July	Jan.	·285
Toronto	Dec.	July	·271	Aug.	Feb.	·380
Hobart Town	July	Dec.	·218	Feb.	July	·125

(*Page* 158.) These differences are large quantities; but we see that as the maxima of P correspond in point of time with the maximum of V, it is only their differences which constitute the total or observed annual fluctuation of barometric pressure. Since, as observed, the annual fluctuation of V is the result of an excess of supply over expense in one hemisphere, and of expense over supply in the other, it may very well happen that the annual fluctuation of V in certain localities may exceed that of P, and, being in a contrary direction, may either neutralise the fluctuations of the gross pressure P + V, or convert it into one of an opposite character. This, however, is rarely the case,

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and where instances of it do occur, as at the Sta. Fé de Bogota and Bangalore, they are for the most part readily enough accounted for by the influence of local peculiarities. If we consider that, in general, the values of P and V, regarded independently, fluctuate in opposite directions, and hence the maximum of the one corresponds, or nearly so, in epoch with the minimum of the other, we shall easily see that, representing P by—

$$P = A + B \sin.(\theta + C) + B' \sin.(2\theta + C') + \&c.$$

we shall have at least approximately for V an expression such as—

$$V = \alpha + \beta \sin.(\theta + C + 180^\circ) + \beta' \sin.(2\theta + \gamma') \&c.$$

the value of C in the term θ differing by 180°, while those in other terms ($C'\gamma'$, $C''\gamma''$, &c.) may or may not stand to each other in a similar relation—the only condition being that they shall be such as to render the co-efficients BB', $\beta\beta'$, &c., all positive. The gross pressure P + V then will come to be expressed by the form—

$$P + V = (A + \alpha) + (B - \beta) \sin.(\theta + C) + M \sin.(2\theta + N) + M'' \sin.(3\theta + N'), \&c.$$

Since $B' \sin.(2\theta + C') + \beta' \sin.(2\theta + \gamma')$ may always be reduced to the form—

$$M \sin.(2\theta + N), \&c.$$

Thus we see that the tendency of the cotemporary action of the two elements composing the gross pressure is—1st, to produce a mean annual pressure $(A + \alpha)$ equal to the sum of the separate pressures; 2ndly, to subdue the influence of the term depending on θ by reason of the opposition of signs affecting B and β in the joint co-efficient B and β; and thus, 3rdly, to give a greater comparative influence to the terms depending on 2θ, 3θ. Now it will be observed that a series thus constituted of series of θ, 2θ, &c., when made to run through its whole period by varying θ from 0 to 360°, will have only a single maximum and minimum when the co-efficient of sin. $(\theta + C)$ is large in comparison with those of the other sines; but when the contrary is the case, a double, or even triple or multiple maximum and minimum may result from such (*Page* 160) mutual relations among the co-efficients as may very easily occur. The principal terms nearly neutralising each other by their mutual opposition, leave the general character of the law of periodicity of the compound effect to be decided by the relations *inter se* of the subordinate ones, and thus is explained, without prejudice to the general reasoning in arts. 77, 78 [pp. 71–73] (which remain true as regards the form of the atmosphere as disturbed by the sun's action), the fact, which appears on first sight in opposition to that conclusion, that the annual oscillation of the gross barometric pressure presents in a great many localities the phenomenon of a double maximum or even a still more complex character. Thus, in Paris, to take a single instance, from a mean of eleven years' observations (1816–1826) the total pressure exhibits two maxima, in January and in July, the former being highest; and two minima, in April and October, the latter being (*Page* 161) the lowest. In the same way the diurnal oscillations may be accounted for. To simplify our conception of the diurnal oscillation we will suppose the sun to have no declination, but to remain constantly vertical over the equator. The surface of the globe will then be divided into a day and a night hemisphere, separated by a great circle passing through the poles coincident with the momentary horizon, and revolving with the sun from east to west in twenty-four hours. The contrast of the two hemispheres, both in respect of heat and evaporation, in this case will evidently be much greater than in that of art. 165 (p. 156), and therefore the dynamical cause, the motive force transferring both air and vapour from the one to the other, will be much greater. But, on the other hand, much less time is afforded for this power to work out its full effect; and long before this can be accomplished for any locality the circumstances are reversed and a contrary action commences. The causes, then, and the mode of their agency, are perfectly analogous in the production whether of the annual or diurnal oscillation; but

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in the former the feeble acting cause is aided by the very much greater length of the period; in the latter, its superior intensity is in great measure neutralised by the (*Page* 162) frequency of its reversal. There is another consideration, moreover, which cannot be without a great effect in establishing a distinction between the two cases. By far the larger portion of the land is distributed over the northern hemisphere, and of the water over the southern. The former is more uniformly terrene, the latter is more uniformly aquatic; and as, under the circumstances now considered, the transfer of air does not take place in the direction of meridians, but at right angles mainly to their direction, we should be led to expect that the amount of counteraction in the diurnal fluctuations of the dry pressure p by those of the wet v would be, generally speaking, very different in the two hemispheres, and that therefore the extent of fluctuation in the gross pressure $p+v$ would, generally speaking, present a corresponding difference. A sufficient amount of observations has not yet been accumulated to bring this conclusion to the test of experience; but we cannot help remarking that the very same cause (the excess of water on the southern hemisphere), acting according to the difference of conditions, ought in the case of the annual oscillation to result in an average uncompensated action on the dry air, urging it towards the northern hemisphere, and to its replacement, bulk for bulk, by vapour, which being lighter than air, [is assuredly one, and it may be the most efficient] of the causes of the generally lower atmospheric pressure over the Southern Ocean—a certain percentage of the due proportion of dry air (*Page* 163) being permanently driven out and prevented from returning by the constant outflow of vapour. That the double maximum and minimum of the barometric march really originates by the approximate destruction of the second term in the series—

$$(A + \alpha) + (B - \beta) \cdot \sin.(\Theta + C) + \beta \cdot \sin.(2\Theta + \gamma), \&c.$$

owing to the opposite march of the dry and wet elements of the total pressure, has been put out of doubt by the calculations of Dove. Yet there are localities where there is an apparent double maximum in the dry-pressure itself. We have seen that moisture in (*Page* 169) the form of clouds, or even in that excessively divided yet unevaporated state which is sufficient to injure the transparency of the atmosphere, and which must be confessed to belong to the yet unresolved problems of meteorology, produces absorption of the sun's rays and the conversion of sensible into latent heat. The diurnal march of temperature, then, in the general atmosphere, is intimately connected with its hygrometric state, and especially with its degree of relative dryness. And for the same reason that the heat of the day is mitigated by the evaporation of the diffused moisture, so is also the cold of night by its deposition, and hence arises a phenomenon of very general prevalence, viz., that the difference between the daily and nightly extremes of temperature or the extent of its diurnal fluctuations is greater in summer than in winter; or rather, to speak more generally and in language applicable alike to inter- and (*Page* 170) extra-tropical localities, in those seasons when the air is relatively drier or moister. In fact, it is evident that when the air is relatively dry, evaporation during the day is more active, and a larger portion of the incident heat becomes latent. On the other hand, as it is necessarily the dew-point which limits (at least approximately) the temperature of the lowest stratum at night, since in the act of condensation the vapour gives out its latent heat, and therefore so long as the supply is continued prevents its further depression the further removed from saturation the air is, the greater depression can be effected by radiation before that limit is reached. The near coincidence of the dew-point with the lowest nightly temperature, at every season of the year, has been shown by Anderson from observations made at Kinfauns Castle during the year 1815; and the calculations of Kämtz show that the difference between the daily extremes of temperature is universally greatest in those months of the year when the (*Page* 171) relative dryness of the air is greatest. The greater uniformity of an insular as contrasted with a continental climate is at least partly referable to the same cause,

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viz., the alternate conversion of sensible into latent heat, and *vice versâ*, by the evaporation and condensation of moisture disseminated through the atmosphere during day and (*Page* 191) night. With the exception of a few very limited regions in which fogs are (*Page* 192) habitually prevalent, and certain points here and there occurring in which rain is almost constantly falling, the general state of the atmosphere is one of more or less hygrometric dryness; so that, as a rule, evaporation may be considered as going on continually over the whole surface of the globe, being only interrupted where that surface is, during certain hours of the night, cooled by radiation below the dew-point. During these the earth is actually abstracting moisture from the air—at all other times supplying it; but far more copiously during the day than during the night. Meanwhile, the very highest regions of the atmosphere being from time to time drained of their moisture by precipitation, there is always a demand for vapour upwards, which is no way intercepted in its ascent by the existence of a region where it assumes for awhile a visible form, and which can only be looked upon as a temporary halting-place, the upper surface of the cloud evaporating while the cloud itself is renewed by condensation of ascending vapour at the lower; unless, indeed, the radiation from the cloud itself should for a time so far lower its temperature as to suspend for awhile, or even reverse, the process. At the epoch of maximum cold, when the surface of the earth is at or near the dew-point, the hygrometric state of the air to a considerable altitude is near saturation, and frequently either a stratus cloud rests on the ground or exists at a much lower (*Page* 193) altitude than in the day; and when this is not the case, still the whole column of air, by reason of the general depression of temperature, is much nearer to its point of saturation than in the daytime. It is the practice of meteorologists to designate by the expression "humidity of the air" the degree of its approach to complete saturation with vapour, and to give precision to this language by attributing to that degree a numerical value, viz., the ratio of the quantity of vapour actually present per cubic foot to that which would exist per cubic foot were the air saturated, or were the dew-point identical with the actual temperature. Thus a scale of degrees of humidity is formed, 1·00 being that of complete saturation, and 0 that of absolute dryness. In this sense of the word it will of course be readily understood that a low degree of humidity is compatible with the presence of a large quantity of aqueous vapour. It is not the vapour as such, but its readiness to be deposited in a wet state on a surface but little lower in temperature, that is intended to be expressed. To obviate the discordance between this language and that of common parlance, the terms relative humidity and relative dryness are sometimes used. As a general meteorological fact, however, there is not merely a want of accordance, but an actual opposition between both the diurnal and annual progress of the "degree of humidity" or "relative humidity" of the air and (*Page* 194) the tension of vapour as indicated by hygrometric observation. To take the case in hand—the diurnal variation—we have seen that at those epochs of the night when the temperature has reached its lowest point, and dew is either actually deposited or nearly so, the humidity is at its maximum. But it is precisely at that moment that the supply of vapour from the earth—having been for several hours cut off, or even a reverse process in progress, while yet vapour has been diffusing itself into the non-saturated regions aloft, and is still continuing to do so—the actual amount of moisture per cubic foot is small, and is still in process of diminution. This epoch is usually a little before sunrise. As the day advances the temperature increases, and becomes more and more in excess of the dew-point. The air therefore becomes relatively drier, evaporation goes on more rapidly, the lower strata become fuller of vapour, as measured by its tension, which at length becomes such as to keep pace with the upward diffusion, which now in its turn is stimulated. The cloud level, or vapour plane, rises, and if the night has been clear, the air calm, the sun powerful, and the soil wet, the appearance of cumuli soon begins to render visible testimony to the nature of the process in progress. When the heat of the day has reached its minimum, the process is in its greatest

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activity. The humidity has now reached its maximum, and the evaporation, which is in the direct ratio of the temperature and dryness, its minimum. From this epoch, (*Page* 195) however, the supply of vapour from below being most copious, while the temperature no longer increases, it is evident that the humidity must begin to increase, while the tension also, for a longer or shorter time, will do the same, until by the decline of the sun the increase of humidity so far puts a stop to the evaporating process as to render it barely competent to supply the expense of upward diffusion, at which moment the tension becomes a maximum, and from which it also decreases, and continues to do so, the humidity increasing during the remainder of the twenty-four hours until next sunrise, when the same cycle of causes and effects will recur. Such at least will be their succession in calm and clear weather and in a normal state of circumstances; and as regards the generally contrary march of the relative humidity as compared with that of the temperature and the vapour tension, such is really the course of the phenomena. The epochs, however, and the order of priority, are obviously very liable to be disturbed by a variety of circumstances, among which the most influential are rain, winds (especially such as recur in daily periodicity, as sea and land breezes), and cloud, which cuts off the sunbeams from the soil and puts a stop to the increase of evaporation before the temperature has attained its maximum, thereby tending to bring the epoch of maximum tension towards coincidence with that of maximum heat. We find, for example, on comparison of the three elements in question, as derived from six years' (*Page* 196) two-hourly observations at the Royal Observatory at Greenwich (1842–1847), the following results:—

	Maximum.		Minimum.	
Temperature .	55·22° F.	1 h. 20 m. p.m.	44·85° F.	4 h. 10 m. a.m.
Vapour tension .	·345 in.	1 h. 20 m. p.m.	·303 in.	3 h. 40 m. a.m.
Humidity . .	·938	4 h. 30 m. a.m.	·753	1 h. 20 m. p.m.

where it should be observed that the amount of cloud at Greenwich is a maximum at 0 h. 20 m. p.m., at which hour 73 per cent. of the sky, on a general average, is covered; and a minimum at 9 h. 44 m. p.m., when 60 per cent. of cloud prevail; the general average of the year being two-thirds cloudy. The annual march of humidity and vapour tension, as compared with that of temperature, depends on the same principles, and is governed by the same laws; the humidity, however (as is also the case with the diurnal cycle), being much more regular in its progress than the vapour tension, and the limits between which the latter element oscillates being much wider, as might be expected from the greater duration of the cycle, and the consequently longer time given for the causes in action to work out their full effect before removal. Thus at Greenwich the annual maxima and minima and their approximate epochs, as appears from the series of observations already referred to, are for the

	Annual Maximum.	Annual Minimum.
Temperature .	63·37° F. in July	34·20° F. in Jan.—Feb.
Vapour tension .	·466 in. in July	·195 in. in Jan.
Humidity . .	·930 in Jan.	·783 in June

(*Page* 197) Locally and temporarily nothing can be more capricious than either the humidity or vapour tension as we ascend into the higher regions. Meteorologists, from Saussure and De Luc downwards, have sought in vain for anything like a regular law of decrement like that which, at least approximately, prevails respecting temperature. Mr. Rush relates that in his sixteenth ascent to the height of 19,400 feet in the Nassau balloon, June 29, 1850, with Mr. Green, they traversed a stratum of air 8600 feet in thickness, in which absolute hygrometric dryness, the zero of vapour tension, existed. This must of course be received with some reserve; but it suffices at least to show that in regions of the globe where cloud is the rule and pure sky the exception, masses of air are occasionally intermingled with the generally moist atmosphere, which would seem

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to have been all but absolutely drained of their moisture, either by long sojourn in the polar regions or in the highest and coldest strata of the atmosphere. Meanwhile, at the ordinary levels we know little at present of the average or climatic distribution of aqueous vapour. Of some things, however, we may be certain, viz.: 1st, That on the open ocean, far from land, the dew-point in the daytime can never be many degrees below the actual temperature of the air, and at night must always be very nearly identical with it. 2ndly, That the mean vapour tension in hot climates must neces- (*Page* 198) sarily be greater than in cold. 3rdly, That, *cæteris paribus*, the relative humidity of the air must be a maximum over the sea and a minimum in the interior of continents, especially where there is much sand, which allows the rain-water to sink, and which speedily dries at the surface; or much bare rock, which, never being more than superficially moistened, affords no supply of vapour to the air. For it is obvious that in such regions there must be less evaporation for an equal incidence of sunbeams; that, therefore, less of the heat will become latent, and their efficacy in heating the air will be in consequence greater, so that the temperature will rise in the daytime faster than the dew-point, and that in an increasing ratio; and, moreover, that from the very combination of these causes there will be less tendency to the formation of clouds over such regions, and therefore a greater amount of direct sunshine thrown on the soil. Thus we have a system of mutually reacting causes and consequences, all tending to exaggerate both the heat of the climate and its relative dryness; the only counteracting power being that of radiation, both diurnal and nocturnal, but especially the latter. Where, in addition to all these causes, those winds which blow from warmer regions or from tropical seas, before arriving at the place in question, have to pass over lofty mountain ranges, and have been chilled in so doing, and drained of their moisture by the precipitation of snow or rain, it may well be imagined that a (*Page* 199) state of extreme aridity will prevail. 4thly, and lastly, we may perceive that the upper regions of the atmosphere—not only as being colder, and therefore incapable of retaining without deposition a quantity of vapour equal to that of the lower —must be habitually and on a general average drier than the lower; though the existence of cirrus clouds at very high levels (certainly sometimes exceeding 30,000 feet) sufficiently proves that even at such altitudes saturation with moisture occasionally takes place. During the sojourn of Mr. P. Smyth on the Peak of Teneriffe the aridity of the air was found to be always excessive. On one occasion at Guajara (alt. 8843 feet) the depression of the dew-point below the temperature of the air was observed to be no less than 54° F. In actual cloud (although in the earlier history of hygrometry the fact was questioned owing to the imperfection of hygrometers used) both common sense and observation go to prove that the extreme point of humidity is attained, since where water is bodily present in every cubic inch of air, and refuses to disappear by evaporation, a state of absolute saturation must exist. Hence we are led to some singular enough conclusions with respect to the law of decrement of humidity as distinct from (*Page* 200) vapour tension. In the daytime, so long as the sky is cloudless over any spot, it is evident that there is no point in the aërial column above it at which the dew-point is surpassed so that the supply of moisture from below is carried off by diffusion upwards, and it will depend entirely on the copiousness of this supply, and the rapidity with which it ascends into the higher regions, whether, as the day advances, the vapour tension and humidity shall follow a contrary or similar progression. If the supply be abundant and borne up rapidly to a colder level, a cloud will be formed, and it is obvious that for some time before its actual visible appearance the air in that region where it is about to be formed must be gradually approaching saturation, and attain it at the moment of deposition of the first molecule of water in a liquid state. From the ground, then, up to the vapour plane, wherever such plane exists, whatever be the law of vapour tension, the humidity (with, perhaps, some interruptions in respect of regularity) continually increases up to 1·00, its natural limit, which it maintains

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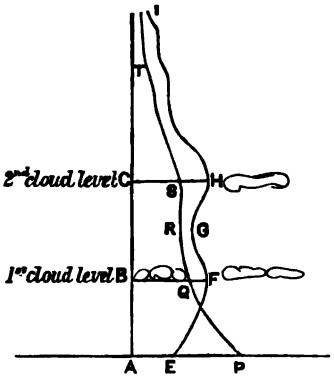
through the whole thickness of the cloud stratum. This surface passed, the upper surface of the cloud performs, to all intents and purposes as regards the higher atmosphere, the office of a lake, being a thoroughly wet surface on which that atmosphere reposes. Henceforward the law of decrement of moisture will be the same as (*Page* 201) it would be over the sea itself under the same circumstances of temperature and pressure. Nor does anything prevent (the sun striking on and evaporating it) why a second layer of cloud should not be formed again at a higher level, and so on—a phenomenon, in fact, of no rare occurrence. In such a case, if we take the height for an abscissa, as AB, the curve of humidity will be an undulating one, such as EFGHI, attaining its maximum 1·00 (= BF or CH) at F or H, and having a minimum between them as at G, while the curve of tension PQRST follows a progression totally different, the relation between any pair of their respective ordinates CH, CS being that which subsists between the temperature, tension, and humidity generally, a relation expressible by the equation



$$V = H \,.\, \phi\,(t),$$

where V is the vapour tension, H the humidity, and $\phi\,(t)$ the function of the temperature t, which expresses the force of saturated vapour at that (*Page* 203) temperature. The winds are originally caused by the equatorial heat and generation of aqueous vapour, or by extensive local agencies of the same kind elsewhere. (*Page* 204) Dove, in his 'Meteorologische Untersuchungen' (1832), has succeeded in exhibiting in a very distinct manner, by an extensive induction from observations in almost every region of the globe, the close and immediate dependence of all the three great meteorological elements, temperature, moisture, and atmospheric pressure, on the direction of the wind. In other words, assuming Θ to represent the angle which that direction makes with the meridian of the place, any one of these elements is found to be expressible on an average or mean value during a whole year or series of years by the equation of the form—

$$E = A + B_1 \,.\, \text{sin.}\,(\Theta + C_1) + B_2 \,.\, \text{sin.}\,(2\,\Theta + C_2) + \&c. \quad . \quad . \quad (a)$$

The mode in which a law of this kind may originate is not difficult to understand. Suppose, first, the earth without diurnal rotation and the sun to move round it from east to west, and at any given spot (suppose in the north hemisphere) let a wind blow direct from the south with a certain force and during a certain time, this will bring over the place of observation the warmth and moisture of a latitude more southerly (suppose) by 10°. But from the eastward or westward of south, at an angle Θ with the meridian, the atmosphere of a place 10° remote, measured in a great circle, will be still transferred to the place, but owing to the inclination of the path only $10° \times \cos.\,\Theta$ more south. If, therefore, the former wind brought with it an accession of temperature or moisture, represented by e, this will bring the accession $e \,.\, \cos.\,\Theta$ proportional to the difference of latitude travelled over. It may happen, however, from the circumstances of the locality that the warmest or moistest region in the neighbourhood may be not due south of the place, but in a direction making an angle $90° - C$ with the meridian. In this case, then, the extraneous temperature or moisture so induced will obviously be represented, not simply by $e \,.\, \cos.\,\Theta$, but by $e \,.\, \cos.\,(\Theta + C - 90°)$, or $e \,.\, \sin.\,(\Theta + C)$. As the effect of the earth's diurnal rotation is to cause the wind to ever, the wind from the southern region will have more or less westing in it at the place according to circumstances. The effect of a wind will depend upon its degree of frequency and duration. Dove and others find

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(*Page* 207) that in the wind rose there are two points not far from diametrically opposed to each other; the one in the neighbourhood of the N.E. point, the other in that of the S.W., from which, when the wind blows, on the long average, both the temperature and the vapour tension have their maxima and minima, the former at the N.E. and the latter at the S.W. The same, or nearly the same, points indicate reversely the maximum and minimum of barometric pressure. There are deviations according to localities. On (*Page* 208) the whole, however, for each locality and for each of the three elements in question it is found practicable to represent its variation in terms of the azimuths Θ of the direction of the wind by the expression

$$E = A + B_1 . \sin. (\Theta + C_1) + B_2 . \sin. (2\Theta + C_2).$$

in which C is very nearly the same angle for all of them, and in which B_2, the co-efficient of the term of the second order, is found to be smaller in comparison of B_1, that of the first. And it is evident that the total barometric pressure P + V and the vapour pressure V, having both this form of expression, their difference P, or the pressure of dry air, will admit of a similar one by a proper determination of its co-efficients, which are easily deduced from those of its component elements by putting

$$P_0 + P_1 . \sin. (\Theta + C_1) + P_2 . \sin. (2\Theta + C_2) + V_0 + V_1 . \sin. (\Theta + C_1) + V_2 . \sin. (2\Theta + C_2) = P'_0 + P'_1 . \sin. (\Theta + C'_1) + P'_2 . \sin. (2\Theta + C'_2),$$

where P′ represents the mixed pressure and the several numbered and accented letters the respective co-efficients of the general formula, and which, reduced by the usual trigonometrical transformations, afford equations by which any one set of these (*Page* 209) values may be easily derived from the other two. It is evident, moreover, without any calculation of this kind, that since the elastic power of the vapour has its maximum at the S.W. point, where the total barometric pressure has its minimum, the dry pressure P must have its minimum there also; in other words, that C_1, being approximately $= C_1 + 180°$, C′ will be nearly identical with C. Dove further finds that these co-efficients are severally and separately, like all meteorological local elements, periodical functions of the season of the year or of the sun's mean longitude. A similar set of relations ought to subsist in the south hemisphere, *mutatis mutandis*; that is to say, with the maxima and minima at south-east and north-west. As an example of the results obtained in this branch of meteorological inquiry we shall here set down the values of the co-efficients in the expression $E = A + B_1 \sin. (\Theta + C_1)$, &c., as calculated by Prof. Johnson from the series of meteorological observations made under his superintendence at the Radcliffe Observatory at Oxford. These are (Radcliffe Obs. 1854, p. xxvi) for the

	A.	B_1.	C_1.	B_2.
Temperature, T.	48·60° F.	2·34°	254·35°	0
Dry pressure, P.	29·404 in.	·108 in.	75·33	0
Vapour pressure, V.	·307 in.	·026 in.	259·39	0

where it will be noticed that 180° + 75° 33′ = 255° 33′, and therefore, conformably to the theoretical views above delivered, the dry pressure has its minimum very nearly corresponding to the maximum of temperature and of vapour pressure. Whenever, as in this case—which is the most common—the terms of the second and higher orders are inseparable, or nearly so, the coefficient B determines the maxima and minima, so that the respective values of $2 B_1$ will express the total amount of fluctuation in temperature, pressure, &c., at the stations which have their origin in changes of wind. It is very easy to perceive that, with this dependence of the great elements of the weather upon the direction of the wind, the other features which stand to them in the relation either of immediate consequences or proximate causes must go hand in hand, such as cloud, rain, &c. For instance, at Karlsbad, from the calculations of Eisenlohr it appears that during the prevalence of south wind, one day out of 17·29, on an average,

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(*Page* 211) only is free from cloud, and during that of north-east one out of 3·04; the intermediate winds being accompanied by intermediate degrees of frequency. So also for the other elements. The tables at the end of this work afford numerous (*Page* 212) and striking exemplifications of these laws, especially as regards the contrary march, both annual and diurnal, of the humidity and vapour tension, the greater range of the annual as compared with the diurnal fluctuations, and the dependence of the average amount of the vapour present in the air, and the extent of both kinds of fluctuation in the latitude.

(*Page* 230.) In describing the cause of polarisation of skylight, he decides it cannot be due to the refractive action of ice, nor of water, nor of reflection of air upon air. Newton's explanation is the least unsatisfactory; he assigns it to the reflection of light on their transparent particles. [H. does not say more, but seems to hint that these particles are vapour, as he states that its explanation will probably be found to carry with it that of the blue colour of the sky itself. If so, then it may be that facts connected with this subject which are given under "Climate: Luminous Rays" may afford clues as to the distribution of vapour. At present the connection is not sufficiently clear to warrant notes being entered here; but when the phenomena of polarisation afford data of this kind such notes may be given here.]

(*Page* 236.) In certain phases of an auroral display indications of a very unequivocal character are afforded of a distribution of a material substance in forms which, could they be seen under ordinary circumstances, would be called clouds. We allude to those luminous bands extending across the sky, and patches of auroral light which are either stationary or nearly so in the sky, but which, when attentively watched, are usually perceived to be slowly drifting southwards. These, perhaps, belong to com-
(*Page* 237) paratively less elevated regions, and are, perhaps, in some cases identifiable with the very highest perceptible cirrus cloud.

Proc. Brit. Meteor. Soc., vol. i. 1863. (No. 2, for Jan. 1862.) (*rv.*)

(*Page* 116.) Notice of "Meteorological Tables," by G. H. Simmonds. 1861.

(*Page* 117.) Table XVII. shows the weight in grains of a cubic foot of vapour, assuming that at 212° it weighs 257·13 grains. Table XVIII. shows the weight of a cubic foot of air saturated with moisture under a pressure of 30 in. from −20° to +120°.

(*Page* 129.) Fisher, in 1845, says that the principal displays of the aurora occur in the vicinity of the edge or margin of the Frozen Sea, and that it is an electrical phenomenon, and arises from the positive electricity developed by the congelation of these [humid (by Editor of Proc.)] vapours, and the consequent induced negative electricity of the upper and surrounding portions of dry atmosphere. It is the accompanying indication of the restoration of the electrical equilibrium, which equilibrium is restored by the intervention and conducting power of minute frozen particles, which particles are rendered luminous by the transmission of electricity. In early winter, before the sea was frozen over, the aurora had a diffused character. As the winter advanced and the edge of the ice became more remote, so the aurora diminished in splendour, assumed a low arched appearance, and was seen only in the direction of open waters. Its height above the surface of the earth is very inconsiderable in high latitudes. The sudden deposition of extremely minute frozen particles when auroral displays took place near to the zenith was several times observed by the author. Joslyn, in 1838, states among other conditions that it [the aurora] requires for its development a cold adequate to the crystallisation of aqueous vapours; that crystals of snow more minute and simple than those which produce halos, are always present in the atmosphere, above the region of ordinary clouds, during the appearance of this meteor. Fisher considers that perhaps the strongest proof of the important agency of these particles in an auroral display is to be derived from the fact that the auroral light can be distinctly traced to those localities where humid vapours

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are known to be undergoing rapid congelation, and where such particles must in consequence abound, and that in the usual arch formation, whatever may be the nature of the night, yet the auroral fringe clearly arises from the illumination of the frozen particles which are formed from the extreme portion of the vapours being under the influence of the cold atmosphere immediately above them. Fisher obtained sufficient evidence of the direction of the situation of the open water from the dark masses of vapour known as sea-blink. The upper limit of the auroral arch was generally dark and dense, as if charged with humidity; the lower, being nearer the water surface, was warmer and more transparent. When ice breaks up by the action of spring tides, and water is suddenly exposed, a difference of more than 70° F. is often found between the water surface and the atmosphere immediately over it; so that the latter becomes immediately impregnated with the extremely minute frozen particles known as frost-(*Page* 130) smoke; and he conceives that the alternate opening and closing of the ice, by which means different portions of vapours are detached from the surface of the sea consecutively, give rise to the appearance of different concentric arches of aurora. Vertical streamers are columns of icy particles in the act of restoring equilibrium between higher and lower strata. Low temperature and humidity are, in his opinion, the conditions required for the production of aurora, and hence the water limits of the Frozen Sea will be most favourable to the production of the aurora, from the circumstance of there being there the greatest supply of humidity. He infers that the auroral zones will not approach nearer the poles than the margin of fixed ice, for lack of humidity.

(*Page* 135.) De la Rive considers he was the first to notice the close connection between auroras and the small icy particles suspended in the elevated regions of the air. Secchi concludes that the character of winter clouds in the polar regions is different from that of the ordinary clouds, and that the appearance of these latter clouds at the poles is a signal, the harbinger of the fine season and of humidity, whilst the auroræ then disappear; that the aurora does not appear unless when the weather is humid; that even when the sky in the polar regions appears limpid it is nevertheless filled with small icy particles. The fact that the aurora is contemporary with a very dry atmosphere, the temperature of which is below 0°, containing small icy particles, may be considered beyond all doubt.

Proc. Brit. Meteor. Soc., vol. i. 1863. (No. 2, for Jan. 1862.) (*rv.*)

(*Page* 167.) Espy (1834) believes that all the phenomena connected with storms are explained by the following theory. When the air in any locality acquires a higher temperature or a higher dew-point than that of surrounding regions, it is specifically lighter, and will ascend; in ascending it comes under less pressure and expands; in expanding from diminished pressure it grows colder—about a degree and a quarter for every 100 yards of ascent; in cooling as low as the dew-point (which it will do when it rises as many hundred yards as the dew-point at the time is below the temperature of the air in degrees of Fahrenheit) it will begin to condense into cloud; in condensing its vapour into water or cloud it will evolve its latent caloric; this evolution of latent caloric will prevent the air from cooling so fast in its further ascent as it did in ascending below the base of the cloud now forming; the current of air, however, will continue to ascend and grow colder about half as much as it would do if it had no vapour in it to condense; and when it has risen high enough to have condensed, by the cold and expansion from diminished pressure, one-hundredth of its weight of vapour, it will be about 48° less cold than it would have been if it had had no vapour to condense nor latent caloric to give out—that is, it would be about 48° warmer than the surrounding air at the same height; being lighter it will ascend and spread out gradually, overlapping (*Page* 168) the air all round and causing the barometer to rise around the storm and to fall in the centre, and, being under less pressure, will ascend, carrying the vapour it

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contains with it, and so continue the process of cloud-forming. The phenomena of tornadoes, hailstorms, and whirlwinds may all be explained by the theory, and whatever cause induces an up-moving current of air in a calm saturated condition of the atmosphere produces rain. Mackay in a letter describes how, in 1845, during a survey, he set fire to a patch of grass, and confined the flames to it. Soon a refreshing breeze sprang up, and a refreshing shower occurred. Capt. A. Mackay afterwards observed that he noticed the formation of a cloud at the apex of the smoke, and said it suggested Espy's theory to him. Accordingly it was determined to put the idea to the test. During a period of unusual heat and dryness, and on a cloudless day, we (states Mackay) told the (*Page* 170) negroes we could bring rain. We set fire to the grass. As the smoky column broke the cloud began to form. Then it thundered, and the cloud spread, and the rain descended in torrents, though the clear sky could be seen in all directions under the cloud. We often fired the sawgrass marshes, and whenever there was no wind stirring we were sure to get a shower; if there was wind there would be the appearance of rain on the horizon. Mr. A. H. Jones says he has performed similar experiments with success, and farmers in the dry season frequently fire the grass in order to get rain. By means of a nepheloscope Espy made experiments on the degree of cold produced, both in dry air and in moist, by sudden expansion from diminished pressure. He found that air in contact with water in a closed vessel will not saturate itself with water, or if saturated will cease to be so after a few days; that vapour permeates air from a high to a low dew-point with extreme slowness, if indeed it (*Page* 171) permeates at all; and that vapour rises into the regions where clouds are formed only by being raised up by ascending currents of air containing it. The manner in which up-moving currents of air carry vapour with them may be seen in the formation of cumuli during a hot summer's day, when the summits increase by the addition of thin films of cloud, produced by the air immediately above, the cloud being pushed up, and the cold of expansion from diminished pressure causing its temperature to sink below its own dew-point. Dissolving clouds frequently occasion strong winds at the surface of the earth; they are termed wind-clouds by the farmers in America. The air on the outer body of the trade winds is remarkably dry, and thus to some extent contribute to the greater height of the barometer there. The upper trade at the equator carries very little vapour in it, as, before it rises over the equatorial regions to one-third of the height of the atmosphere, nearly all its vapour is condensed into clouds, and therefore, when it rises above the clouds and rolls off to higher latitudes, it carries with it but little vapour. In short, the air does not carry so much vapour to high latitudes as the air below to the low latitudes, and when it descends to the surface it (*Page* 172) appears very dry, as its capacity for vapour is greatly increased by the heat of compression. Cloud is never formed except in an up-moving current, for air coming downwards always becomes drier; and if it be supposed that cold air in the same horizontal level should mingle with warm so as to produce condensation of vapour, the evolution of caloric in this air would immediately diminish its specific gravity, and it would begin to ascend. Wherever there is an up-moving column of air sufficient to form a large cloud, there is of necessity a down-moving current of air all round it; and where this current reaches, it is clear, if any clouds existed at first, they are soon dissolved by the heat of compression. Were it not for this cause there are large regions of the torrid zone which would be covered with eternal cloud.

Proc. Brit. Meteor. Soc., vol. i. 1863. (No. 3, for March 1862.) (*rv.*)

(*Page* 182.) The object of Glaisher's balloon ascent from Wolverhampton on March 22, 1862, was to determine the distribution of moisture throughout the atmosphere, but the balloon failed.

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1863.

Airy, J. B. *Proc. Brit. Meteor. Soc.*, vol. i. 1863. (No. 8, for June 17.) (*rv.*)

(*Page* 365.) Bloxam does not seem to have fixed his attention on the supposed error Lamont endeavoured to correct. I apprehend Dalton's experiments amount to this: "In a limited space, of such a form as is very favourable to the motion of masses or particles of gas, the dry air and the aqueous vapour exist through the whole space, each exerting the same elastic pressure as if the other was not there." In ordinary (*Page* 366) quotation this law has been cited to some such effect as the following:—"In any spaces we may consider separately the law of distribution of vapour as that of an elastic gas, supposing no air present; and the law of distribution of air as that of an elastic gas, supposing no vapour present; and we may represent the actual state by combining these two gases in the densities thus indicated." For instance, the hygrometer shows a great density of vapour near the ground. It has been supposed that the density of vapour in every stratum above it can be computed from that lower density by the same laws as if vapour were the only gas above the ground, disseminating itself by the ordinary laws of gaseous dissemination. I do not know that any one has stated the principle so broadly; some have come near it, and I have no doubt it is the latent idea which guides many meteorologists. It is against this idea of dissemination that Lamont's experiments are directed. He does not dispute that where air and vapour are mixed Dalton's law holds truly, but he shows that the dissemination does not at all take place according to the law of simple elastic gases. A gas, if no other gas were present, would with great rapidity disseminate itself into every chamber connected with the place where it is set free. Aqueous vapour, there is no doubt, would do so if it were alone; but aqueous vapour combined with air will long remain in one place, as if the mixture of vapour and air produced viscosity. This is what Dr. Lamont shows.

Blake, H. W. *Proc. Brit. Meteor. Soc.*, vol. i. 1863. (No. 7, for March 18.) (*rv.*)

(*Page* 331.) Describes cirri seen near Welwyn, Herefordshire, on Dec. 14, 1862, which presented auroral appearances after dark. Coupling this with Glaisher's observa-(*Page* 332) tions on the great height of cirri, he suggests that we must look for some other cause for their formation than that of aqueous vapour, especially when the dryness and the extremely low dew-point of those regions are likewise considered. [He implies that cirri may be simply auroras as seen by daylight].

Bloxam, J. C. *Proc. Brit. Meteor. Soc.*, vol. i. 1863. (No. 7, March 18, 1863.) (*rv.*)

(*Page* 324.) In discussing the occurrence of the black-thorn winter in spring, he concludes that it is not due to any retrogression in the temperature. We must then seek for some other peculiarity that will serve to account for the sensible character of the season. [He does not say to what place his observations refer, but I presume it is Newport or some place in England. The general principle underlying the figures and discussion is of wide application.] What is the hygrometric state of the air? The mean temperature of the dew-point for the year, which is 43°, occurs on May 12; the mean value for April is 38°·6, that for May 44°, and the value for April 21 is 38°·9. The daily rate of increase for April is 0°·09, and that for May 0°·23—the mean rate from lowest to highest being 0°·12. On April 21 the dew-point temperature has risen 25 per cent. of its total annual rise, but the atmospheric temperature has risen at the same date 39 per cent. On April 21 the humidity is at its minimum value for the year, viz., 71·1. This is the essential fact which solves the problem; the 21st of April differs from every other day in the year in this respect, and the black-thorn winter reaches its

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culminating point on this date; the evaporation produced by this low degree of humidity gives rise to that peculiar feeling of cold which characterises the season. But this excessive evaporation depends as much upon the high temperature of the atmosphere as upon the low temperature of the dew-point. The sky is far more clear of cloud than on the average, but it is not at its minimum; the lowest value for this particular is 6·0 on (*Page* 325) Sept. 4. The heat from the sun's rays at this period of the year is great, owing to the transparency of the atmosphere and the clearness of the sky; this perhaps renders the sense of coldness the more conspicuous and distressing. The low value for humidity is thus shown to be the dominating characteristic of the equinoctial winter. At this season of the year a great advance is observable in temperature, and the peculiarity of the season is explained by the fact that it is the period of the year in which the temperature rises to its highest point with an arctic atmosphere; the temperature continues to rise subsequently as the north declination of the sun increases, but this progress in the sun's position brings to our latitude in the temperate zone a moist as well as warm tropical atmosphere. The tendency in the atmosphere to flow from the north-east quarter is at its maximum intensity on April 19. At the period of the year which is under review the source from which our atmosphere proceeds is a region of ice, in which the temperature had been much below the freezing-point for months, and the vapour of its atmosphere is reduced to its lowest amount prior to its (*Page* 326) flowing to the lower latitudes. Similarly, as regards the St. Martin's summer the peculiarity of the season is evidently due to some other element than temperature. Dec. 3 is marked as having the maximum humidity for the year. On Nov. 9 the value is 82·6, and this may be regarded as the day on which the equinoctial or St. Martin's summer culminates, because the humidity attains a high and a maximum value on that day. Excessive humidity and consequent defective evaporation are the cause of the sensible warmth which attracts attention. The south-west wind has the ascendant during the season. The amount of cloud is great during the season, though not at the maximum. The high value for humidity is assuredly the essential meteorological characteristic of the equinoctial summer, and this high value seems to be brought about in a great measure by the rapid decline of temperature. May the low temperature of the atmosphere and the comparatively high temperature of the dew-point be explained by the fact that the atmosphere proceeds from higher latitudes than it does during our summer, and from cold land districts; but whilst crossing the Atlantic it takes (*Page* 362) up a large quantity of vapour? (No. 8, for June 17.) Lamont's article does not afford a definite decision as to the relation of the atmospheric aqueous vapour to the air. The aqueous vapour probably does not form an atmosphere totally independent of, nor absolutely dependent upon, the air; the vapour is probably not merely mechanically mixed with the air; it is probably not chemically combined with the air; the connection subsisting between vapour and air, as the two exist together in the atmosphere, may be dependent upon electric conditions. Neither Dalton's theory nor Lamont's theory asserts either the positive or the negative view of either of the propositions absolutely. It is to be remembered that Dalton's theory is not merely a theory; the laws he announced are laws deduced from and clearly indicated by experiment carefully conducted; and he deals with the physical results of the combination rather than the law by which the combination is effected. No one perhaps will at present venture to pronounce on the essential nature of the combination. Professor Lamont's experiments rather confirm the three principal results deduced from Dalton's experiments. "As to the mutual relations subsisting between vapour and air, when they are simultaneously present, the experiments (of Dalton) afford no information." This is, perhaps, not quite a correct statement; but what are the mutual relations indicated by the professor's experiments? They seem to be nothing more than this:—If the portion A of the space AB is occupied with air, and the portion B with vapour, whatever the elastic force of the air may be under this arrangement, the amount of that force will be diminished by withdrawing the

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(*Page* 363) vapour from B, and allowing the same air to occupy the whole of the space AB. The interpretation that Dalton gives to the second of the three propositions is that when air and vapour are mixed together in the manner (though perhaps not in the same degree) that obtains in the atmosphere, neither of the two influences the elastic force of the other, or, more correctly, this is the result obtained by experiment. He gives no such interpretation as that "no mutual relation whatever existed between vapour and air;" he would doubtless have acknowledged such mutual relation as the diagram above refers to. Dalton's theory does not imply that the atmospheric vapour *is* sustained in equilibrium by itself alone, but that it *can* attain to a state of equilibrium by virtue of its gravity only; and its tendency to acquire equilibrium as an independent agent helps to determine its movements and to regulate its quantity in any particular locality. The third proposition properly declares that there is indeed always a tendency to a normal relation "in so far as that each of the constituents has always a normal (though constantly varying) condition belonging to it; but this does not ignore the fact that neither the normal condition nor the normal relation can ever be reached, owing to the law that one of the two bodies is being perpetually exhausted at one point and reproduced at another, which necessarily leads to this one being always in motion and never in equilibrium. It may be strictly true, or it may be true in a limited sense, that "a mass of vapour and a mass of air placed in communication with each other mutually preserve a state of equilibrium without the vapour penetrating into the air or the air into the vapour"; but this is not contradictory to Dalton's theory. Dalton states that the two constituents do not readily mix spontaneously; the professor contrives artificial means to counteract the natural tendency to mixing; but Dalton's theory does not gainsay the possibility of doing this. Dalton's theory is not adverse to the proposition that if air be preserved unmixed in the space A, and vapour be preserved in the space B, the elastic forces of these two bodies will press one upon the other. It is quite clear that whilst each maintains its own separate position, each must press (*Page* 364) against the other where they come in contact. According to Dalton, if as much vapour be forced into a limited space as can exist in that space in the form of vapour, the quantity that can so exist will not be diminished by forcing air into the same space with the vapour, provided the two be intermixed in the manner they admit of. Lamont's experiments or reasoning are not opposed to this. If vapour is slow in diffusing itself through the air, and a portion consequently remains unmixed, this portion will then be subjected to the pressure of the air, and it may then be condensed, although it could not have been so condensed by its own pressure. A mass or layer of vapour may be imagined as held in the grasp, as it were, of the atmosphere, and it would then comport itself the same as if it were enclosed in an elastic bag; it would be subjected to the pressure of the atmosphere. It is probable that masses of vapour (*Page* 365) often exist in the midst of the atmosphere mixed with a comparatively small proportion of air; it would then not press upon the atmospheric vapour beneath in the same manner that it would do if diffused equally through the atmosphere; it would press against the surrounding atmosphere, and the atmosphere would not press upon it. The vapour pressure thus transmitted through the atmosphere would not be distinguishable at the surface of the earth from the air pressure; we should not be able to detect the vapour existing in this state by any of our instrumental aids at the surface of the earth. The Dalton law is correct, but a false interpretation has been given to it by the invention of hygrometers. The hygrometer detects that portion of the vapour pressure only which arises from the vapour diffused through the air; and the quantity of vapour in the air is probably always greater than the vapour pressure indicates; the air pressure must be to the same extent at least less than the estimate. This may lead to the conclusion that the atmospheric vapour is a more powerful agent in giving motion to the atmosphere than it has hitherto been supposed to be. Pure

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Scientific Union.

The rapid progress of science now going on is, in part, the result of the great increase in the number of workers. This is accompanied by a larger and larger host of scientific serials. The consequence is that the student finds an increasing difficulty in ascertaining what has been done, or is in process of being accomplished, not only in his own special line of study, but also, and more particularly, in such as do not immediately interest him. Every student finds, from time to time, that he has a desire for full information on subjects in these outlying sciences, for the purpose of throwing light upon his special studies. The state of literature is such that he is frequently daunted by the difficulties attending his research, or, if he perseveres, he finds a great deal of time unnecessarily wasted. The remedy for this is the focalisation of knowledge round a series of centres. The two main steps in the process are, first, collection, and, next, classification. It is with this ulterior object in view, that all persons interested in meteorology are earnestly asked to forward their names and addresses, particulars as to the work they have done in meteorological and other sciences, their present lines of study, ways in which help is desired, and any other items that may occur to them. These details will be classified, and, when the opportunity offers, selections from them will be published. The Conductor will exercise careful discretion in the selection, as also in the use he may make of the more private details. The first list will be published in November, 1883; but correspondents are requested to send in answers soon, in order to allow of ample time for their classification, and for their utilisation in private correspondence in the interests of correspondents.

In order to prevent any misconception, it may be stated that the Conductor's object is solely to promote scientific union, and is no way intended to be of a charitable nature in any pecuniary sense. If there is a sufficient response to these requests, the same line of proceeding will hereafter be suggested, from time to time, for the students in other branches of science.

Newspapers and scientific journals of all countries, willing to help in this matter, are asked to make the above requests known to their readers.

Address, Conductor, "Scientific Roll" office, 7 Red Lion Court, Fleet Street, London, E.C.

We are glad to find that some attention is being given to the subject of promoting greater unanimity of action amongst our local Scientific Societies; but up to the present time the interest manifested has not been equal to what the importance of the movement demands. In the course of the present session we hope the numerous committees of

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only from individuals that reliable materials can be obtained; consequently, if no adequate response is made, no list of the kind proposed will be attempted.

Communications have been received from Prof. Robert B. Warder intimating that he is compiling a list of papers relating to the speed of chemical action, and the intensity of chemical affinities. There are many papers dealing with these subjects which are liable to be overlooked owing to the titles being of no assistance. All individuals who have made observations on the subjects mentioned would help Prof. Warder by communicating with him. He has two papers on the subject in No. 4 of the 'Scientific Proceedings of the Ohio Mechanics' Institute.' One is on 'A Criterion for Measurements of the Speed of Chemical Action'; and the second is a summary of 'Urech's Investigation of the Speed of Inversion of Cane Sugar.' Any chemist or physicist interested in this subject can have a copy of this number supplied to him gratis on applying to the 'Publishing Committee, Ohio Mechanics' Institute, Cincinnati, Ohio, U.S.A." There is another reason why such persons should put themselves in communication with Prof. Warder through this committee, which is, that it will strengthen his hands to carry out an organised enquiry into the subject, should such an enquiry seem as practicable as it is desirable.

We have also recently received the earlier numbers of 'Science,' and take this opportunity of drawing attention to it, because it is, we believe, the first weekly periodical which has adopted the methodical arrangement which is advocated by the 'Scientific Roll.' As stated in the prospectus issued in No. 5, "this prominent feature will be particularly attractive to the specialist in whatever branch, as he will at once know where to look for the latest information about all the more important work in his own field of investigation." The reviews are severely critical, yet judicious and fair, being as unsparing in blame as in praise, when each seems deserved; the articles are of the highest quality; and the abstracts are compact and pointed, and are drawn up by specialists of high repute. We are glad to see that due prominence is given to the work performed by Government and other organisations, and would refer to the following paragraph as an example, which we hope will be followed in other countries and in other subjects. The paragraph is from No. 10, published on April 13, 1883, p. 291:—

Contagious Diseases of Animals—The subject of the prevention and cure of contagious diseases of animals has for many years been considered in this country. For a long time extirpation was resorted to, and with good results, notably in the work of the Commission appointed by the State of Massachusetts in 1860, which entirely succeeded in freeing that State of pleuro-pneumonia. Of late years inoculation or vaccination has been employed with such success abroad by Pasteur, that we are justified in anticipating most beneficial results from the prosecution of his methods in this country. Pasteur has been engaged in efforts to establish some law through the agency of which such diseases as pleuro-pneumonia, charbon, foot-and-mouth disease, and other diseases of domestic animals, could be controlled and cured. Dr. D. E. Salmon has been pursuing similar experiments under the direction of the U.S. Department of Agriculture, though necessarily in a more limited way, and has met with such success, that he has great faith in the result of the more elaborate and extensive experiments which he is about to undertake in the district of Columbia. Commissioner Loring has determined to place at the disposal of Dr. Salmon the necessary land, buildings, animals, and apparatus to enable him to make the proper microscopical observations, and to carry on any experiments that will tend to establish some economical method by which our farmers or breeders may control the diseases of their animals. Dr. Salmon is of opinion that such diseases as Texas fever, charbon, and pleuro-pneumonia are the results of germs which he has found in his post-mortem examinations, and that it is possible to protect unaffected animals from these diseases by dilute inoculation.

The election of a recorder of economic entomology is another example which we trust will be soon followed in other counties. Mr. S. L. Mosley, Beaumont Park, Hudders-

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"The Council have appointed a committee to consider and report on the question referred to them by the General Committee, and this committee having recommended to the Council 'that they be empowered to confer with delegates representing the societies, to ascertain in what way the Association might be able to aid them in obtaining a better organization and a more effective direction of their efforts in the cause of science,' and the Council having adopted this recommendation, your committee was invited to send one or two representatives to confer with the committee of the Council on the subject. The meeting was held on March 28th, when Mr. Hopkinson and Mr. Fordham attended on behalf of your committee, and the position and objects of the annual Conference of Delegates were discussed at some length. The results of this discussion are embodied in the report presented by the Council to the General Committee on Wednesday.*

"2. The committee have prepared and issued the circular to local scientific societies, with a circular letter, drawing attention to the annual Conference, and to the rule of the British Association under which delegates may become members of the General Committee, asking for a discussion of the circular and enclosures, and giving information as to the Conference to be held at Southampton. With this letter they sent a printed copy of the minutes of the York Conference.

"The circular itself referred to the work of three committees of the British Association (those on underground waters, erratic blocks, and underground temperatures), and to investigations relating to the following subjects:—Rainfall, periodical natural phenomena, and the appearance of and damage done by injurious insects. The following papers were enclosed with it:—Mr. Symons' pamphlet on the 'Arrangements for the systematic observation and record of the rainfall of the British Isles,' a copy of the table of monthly rainfall in Hertfordshire, and the form, with lists of plants, insects, and birds recommended for observation, issued by the Meteorological Society. A selected list of periodical natural phenomena (prepared by Mr. Hopkinson) and a list of injurious insects (from Miss Ormerod's publications) were printed at the end of the circular.

"The special thanks of the committee are due to Mr. Symons, and to the Meteorological Society, for copies of the pamphlet on rainfall, and of the phenological form, and the committee have also to thank the editor of the 'Scientific Roll' for reprinting in his publication the minutes of the York Conference, and the papers issued by the committee. About 200 copies of the circular, with the other papers enclosed, have been sent out to local scientific societies. The committee regret that they have not received many replies to their circular letter; on the other hand, in some cases applications for copies of the papers have been received from societies whose existence was not known to the committee, and no doubt a certain amount of interest has been aroused, and some practical good has been achieved, by putting before a large number of local scientific workers a definite proposal for systematic scientific work. The amount received in 5*s.* subscriptions at the York Conference was £3 10*s.*, and £1 has been since received by the committee. The expenditure up to the York Conference for printing and postage was £2 10*s.*, and the expenditure since incurred in printing and issuing the circular and other papers has been £4 14*s.*, showing a deficiency of £2 14*s.* There will also be some small additional expense in convening the present Conference."

"* The recommendations of the Council, which were adopted, after some discussion, by the General Committee, were as follows:—'(1) The omission in the rules (General Committee, Class B Temporary Members, § 1) of the words "and the Secretary of such Society," which follow the words, "or, in his absence, a delegate representing him." (2) The appointment of a committee in order to draw up suggestions upon methods of more systematic observation and plans of operation for local societies, together with a more uniform mode of publication of the results of their work,' and also, 'that this committee should draw up a list of local societies which publish their proceedings.'"

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The adoption of the report was moved by Mr. Mott, seconded by Mr. Price, and unanimously agreed to.

The change made by the General Committee of the British Association in the rule of the Association relating to the appointment of representatives of scientific societies on that committee, by which the representation is now limited to the president of a society, "or, in his absence, a delegate representing him," was discussed at some length. It was pointed out that the presence of the president of a society at a meeting of the Association, even if only for a single day, and without his taking any practical part in the business of the General Committee, prevented his society being represented by a delegate on the committee, and in order to obviate the inconvenience arising in this and other ways from the wording of the rule, and to place in the hands of societies the direct appointment of their representatives, it was moved by Mr. Price, seconded by Mr. Glen, and unanimously resolved, that steps should be taken to amend the rule, so that it should read, "A delegate appointed by any scientific society publishing transactions." It was left to Mr. Fordham to bring this proposal before the Council and General Committee at the earliest opportunity.

The chairman drew attention to the desirability of obtaining greater regularity and method, and a nearer approach to uniformity of plan, in the publications of societies having similar objects, and undertaking similar work.

After some discussion, Messrs. Meldola, Hopkinson, and Fordham were appointed a committee for making the arrangements for the next Conference, to be held during the Meeting of the British Association in 1883.

It was referred to the committee to obtain one or two papers on subjects of interest to local scientific societies to be brought before the next Conference, in order to insure a regular discussion of special questions, and several matters were suggested as being suitable for consideration by the Conference.

Votes of thanks to the committee and to the chairman closed the proceedings.

THE SYSTEMATIC STUDY OF CAUSES OF SICKNESS AND DEATHS.

BY HENRY B. BAKER, M.D., SECRETARY OF THE STATE BOARD OF HEALTH OF MICHIGAN.

[*Reprinted in part from the Annual Report of the Michigan State Board of Health for* 1881.]

The first and most constant need of the sanitarian is accurate knowledge respecting those most common of all occurrences—sickness and deaths from diseases which during years and series of years have afflicted mankind. If it seems strange that there is so great lack of knowledge on such common subjects, it must be remembered that sanitary science is one of the latest sciences, and that physicians, as such, have had no need to record or to note many of those classes of facts which form the foundation of sanitary science, though some have had occasion to contribute greatly thereto. The prevention of sickness has not been their work, and the collection of facts respecting vast numbers of cases of sickness or deaths involves labour and expense too great to be borne by individuals, unless the knowledge gained thereby is such as will advance the work in which they are engaged. It has not been apparent that sanitary science would greatly advance the art of healing or the science of therapeutics, for which other classes of facts are needed, and for which they have been diligently collected, in times past. Though it is possible that the science of therapeutics might be fostered and advanced

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by governmental aid, there seems to be no especial need for such aid so long as it is for the pecuniary advantage of individuals to perfect their knowledge of therapeutics in order to lead in the practice or teaching of their profession. But with sanitary science the case is very different,—there never has been, and there is not now in this State, any class of persons having such an income from any public-health service by the individual citizen as will permit of any effort for the collection of those facts which are essential to the beginning of sanitary science. In the statement just made I do not forget that progress in sanitary science and improved health-service increases the incomes of individuals generally throughout the State; this is undoubtedly true, but it does so by lessening expenditures and by increasing the ability to labour in ordinary and extraordinary pursuits. It is plain, therefore, that we cannot expect much progress in sanitary science without some such associated effort as that afforded by governments —State, National, and local. The old saying that "what is everybody's business is nobody's business" is particularly applicable in this connection; for though it is readily granted by every one we meet that "health is wealth," that "public health is public wealth," that "an ounce of prevention is worth a pound of cure," and that measures for the promotion of health are of vital consequence to every person, yet, except the government aids, there is now no person who can get a living by labouring for the prevention of sickness.

HOW CAN A GOVERNMENT PROMOTE SANITARY SCIENCE?

The chief duty of a government is to do for the safety of a people whatever they are unable singly or by practicable voluntary associations to do for themselves. If, as is now known to be the case, people die or suffer in great numbers from lack of knowledge which only the government can collect and diffuse among them, evidently it is one of the highest duties of the government to collect and diffuse that knowledge. That hundreds of such deaths have occurred in this State in every year is now established by good evidence.

WHAT KNOWLEDGE IS NEEDED FOR THE PREVENTION OF DEATHS.

Manifestly the first requisite for the prevention of deaths is a knowledge of the causes of the deaths. This has long been recognized by intelligent legislators, and in most civilized countries "vital statistics" have for many years been regularly and systematically collected. The same is true in many of the States of this Union. The history of progress in public-health movements shows that sooner or later the facts thus collected usually lead to some organized work for the prevention of deaths; thus in England, Annual Reports by the Registrar General relative to vital statistics have been published since the year 1838, while Reports by the Medical Officer of the Privy Council date from the year 1858, showing that after the beginning of vital statistics in England, twenty years elapsed before a general Board of Health was established with the view of attempting to systematize the public-health work, and make it more effective. In this country, in Massachusetts, vital statistics have been collected since 1842, and in 1869 a State Board of Health was established for the prevention of those deaths which the vital statistics showed to be most numerous. During the twenty-seven years preceding the establishment of a State Board of Health in Massachusetts, the statistics of deaths and their causes had been collected, published, and studied by citizens of that State, and the evidence was conclusive that many deaths occurred from causes known to be preventable, and many more occurred from diseases believed to be preventable or avoidable. In Michigan, vital statistics have been collected since 1868, and the State Board of Health was organized in 1873,—following the first inquiry for facts more speedily than in the older countries, partly because the vital statistics of Michigan soon showed that in Michigan as in Massachusetts, there were many pre-

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ventable or avoidable causes of sickness and death, and suggested a similar agency for communicating to the people the knowledge necessary to avoid or prevent deaths from such causes. It must not be understood that the vital statistics alone are sufficient to give this important knowledge. It is said that a single bone enabled Owen to construct or reproduce the skeleton and form of an extinct species of animals, and subsequent discoveries of fossil remains confirmed his hypothesis and heralded another of the grand triumphs of mind over the difficult problems with which thinking minds everywhere are engaged. But it was to Owen, the diligent student of anatomy, the close observer of the many ways in which organ is correlated with function, and function with function, the learned teacher of the fundamental laws of structure and of the history and philosophy of structural development—it was to the keen eye and mind of *such* a man, and not to the mere delver in the earth by whose spade the bone was brought to light, that the communicative fossil disclosed its secrets of the past, its vision of the perfect form that should be revealed.

Thus it is not to the mere *compiler of vital statistics* that there is given a comprehensive view of the relations which the various classes of deaths bear to the varying conditions of soil, climate, age, occupation, nationality, social custom, individual habit, and pecuniary circumstances, by which the people of a State are surrounded, and of the various means of prevention or avoidance, direct and indirect, by which it is possible to lessen the death-rate of a State, diminish its burden of sickness, crime, and poverty, prolong the lives of its inhabitants, and promote their comfort, welfare, and happiness.

The man or the body of men who, from its vital statistics, shall construct the public-health service of a State must bring to the task the knowledge which can be acquired only at the feet of the masters of the medical sciences, and in the every-day walks of the physician; the familiarity with the manifold forms and habits of minute organic bodies, both animal and vegetable, which only the biologist has attained; the command of the inorganic substances and forces of nature which is bestowed only in the laboratory of the chemist; the knowledge of the formation and relative position of rocks and soils and of the relations of these to drainage and water-supply which is the reward of the geologist; the knowledge of climate which is the heritage of the meteorologist; the knowledge of the principles of government and of the moral nature of man which characterizes the lawyer; the power of commanding the attention and addressing the conscience of the people which is the glory of the orator and the preacher,—these qualifications and *more* are requisite not only to that study of vital statistics which shall discover the preventable causes of deaths, and elaborate practicable means for their removal or control, but also to that successful adaptation of means to ends by which the people shall be led to adopt and enforce practicable measures for their own protection and safety.

USES OF VITAL STATISTICS.

To vital statistics we are indebted not only for evidence showing the necessity of effort for the prevention of deaths, but such statistics are needed for constant reference in studying methods by which the deaths may be prevented. Before we can act intelligently for the prevention of deaths from any given disease or cause, we need to know the time of year at which the danger is greatest, the ages at which a person is most in danger, to persons of which sex the danger is greatest, whether the danger is greater in one part of the State or country than in another, and many other facts. Vital statistics, accurately collected, compiled, and studied, for a period sufficiently long, will give us such information.

WHAT ARE "CONTRIBUTIONS TO SANITARY SCIENCE"?

It is, I think, just as important to "know a good thing when we see it" in public-health work as in any other affair; therefore it is well to bear in mind that popular books

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and articles are not usually "contributions to science," that papers (such, for instance, as this one) read at public meetings are not usually "contributions to sanitary science," and that really valuable "contributions to science" are not commonly easy and pleasant reading, notwithstanding their high value in advancing existing knowledge. A science is built up by the accumulation of numerous facts, which, ultimately, are grouped so as to exhibit general truths. When an individual or a government collects numerous facts, and skilfully groups those facts so as to lead to new knowledge bearing upon the problems with which public-health work deals, that individual or that government makes an important contribution to sanitary science. However useful it is to have essays on public-health work in all its various departments, and however much good may be done because of the stimulus of such essays, which I consider essential to progress in sanitation, yet it must not be forgotten that the real solid basis of all such work must be laid in the patient, painstaking accumulation of facts (such as physicians are freely contributing), their classification, comparison, collation, provisional grouping, and final grouping so as to serve as bases of action. Thus the recognized basis of sanitary science is statistics—of deaths, of sickness, of meteorological and other surrounding conditions, though very much more than such statistics is needed for an effective public-health service.

USEFUL FACTS FROM THE VITAL STATISTICS OF MICHIGAN.

Facts illustrating the nature of some of the information gained by means of vital statistics already collected in this State, may be given: It has been learned, for instance, that in this State, during a long series of years, the danger from small-pox was not as great as the danger of death from whooping-cough, there being twice as many deaths from whooping-cough as from small-pox (though the proportion of children is greatest among those who die from whooping-cough). It has been learned that diseases of the lungs cause nearly one-fifth of all the deaths reported in this State, and that nearly one-half of all the deaths are attributed to diseases of the lungs, the bowels, and the brain; and it is found that a large proportion of the deaths from each of these three groups of diseases are reported to be caused by tubercular diseases, such as consumption of the lungs, consumption of the bowels, tubercular disease of the brain and coverings, etc., so that if, as now seems probable, sanitarians shall soon be able to class consumption among the preventable diseases, and to teach people how to prevent a considerable proportion of the deaths now charged thereto, it will be one of the grandest achievements of the century; for it will add more to the financial prosperity of the people than can be easily computed, hundreds of thousands of dollars annually now being lost to the people of this State by reason of sickness and deaths from consumption; and then the anguish of human hearts beyond any power of computation or expression!

The deaths reported from consumption in Michigan will average over 1,400 annually, and there is evidence that the number reported should be much increased in order to equal the deaths which actually occur; probably two thousand persons die in this State in every year from consumption. And yet compared with many other States Michigan is a very healthful State, and we are accustomed to regard these deaths as inevitable—indeed, as a rule, they seem to be when once consumption has been contracted; and up to this time no effort has been made to prevent the spread or occurrence of this disease. It may serve to awaken the enthusiasm sufficient to start some effort for its study and restriction, if we consider that consumption is now proved to be communicable from man to lower animals; that there is good evidence that the disease may be communicated from animals affected with it to man—as, for instance, to susceptible children by means of milk of a tuberculous cow, to any susceptible person by means of insufficiently cooked meat of a tuberculous animal; that there are hundreds of tubercular cows and other animals; and that consumption is probably spread among people in unventilated rooms by breathing air which has come from the lungs of persons

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suffering from consumption. The evidence of this last proposition is twofold—because from statistical and other evidence some have been convinced of the truth of it, and lately experiments have shown that dogs will contract the disease if caused to breathe air in which tuberculous matter has been anatomized. Let us place these facts by the side of those others which the vital statistics give us—namely, that, counting all children and grown people in this State, at least twelve per cent. die from consumption—an average equal to every eighth person you meet in this State; and we may add that the death-rate is reported about double this among persons over fifty years of age; thus we begin to see abundant reason for tremendous effort to learn the whole truth, and then for another effort for the prevention of this great waste of human life, which is going on among us.

THE VALUE OF REPORTS OF SICKNESS.

Until recently sanitarians have been obliged to accept as their best guide in the study of the causes of sickness the facts reported concerning the number, time, and alleged causes of deaths; but evidently there is much sickness which does not result in death, but which, nevertheless, it is very desirable to prevent if possible, and there are many deaths having a remote cause in sickness or other conditions quite different from those immediately preceding the death, and likely to be reported as its cause; so that statistics concerning the sickness of a people are no less necessary than those concerning deaths. Weekly reports of sickness also serve to announce to a State Board of Health, outbreaks of communicable diseases, and thus enable the board to direct attention in various parts of the State where such diseases occur, to necessary measures for the restriction and extirpation of the disease. For such timely work by the State Board a system of prompt and regular reports of sickness is essential. Yet it is only for a few years that the attempt has been made to collect statistics of sickness; and at this time I know of no such systematic effort being made elsewhere for the collection of facts respecting sickness as that by the Michigan State Board of Health. This Board receives weekly reports of the sickness under the observation of many of the leading physicians in this State, about one hundred of whom in nearly as many different parts of the State promptly notify the Board of the outbreak of any communicable disease, and regularly report concerning the relative prevalence of cases of each of the prominent diseases under their observation. This makes it possible for the State Board of Health to send promptly to each locality, documents bearing upon the restriction of any particular disease which occurs, concerning the restriction of which the State Board has gained useful information; provided the State Board has the means to print and to distribute documents in that manner; and such distribution is desirable even if the document has been generally distributed before, because, during an outbreak of a disease, many will seek and gain information relating to that disease, who will not do so at other times. But aside from keeping the State Board constantly informed concerning the health or sickness of the people, the weekly reports of sickness have great value as contributions to our exact knowledge on the subject; because the facts thus reported can be systematically arranged, compiled, and joined with other facts similarly arranged respecting the surroundings of people at different ages and at different seasons of the year, and knowledge may thereby be gained which will eventually enable the board to tell the people the conditions under which sickness from each of the prominent diseases occur, and the conditions under which it does not occur,—knowledge which must be gained if we are ever to be able to avoid or control those conditions which are now permitted to cripple and to destroy so many prematurely.

METEOROLOGICAL AND OTHER CONDITIONS MUST BE KNOWN.

In order to build up a sanitary science which shall serve as a basis for the prevention of sickness and deaths, it is essential, as has already been said, to have facts from more

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sources than one. It is not enough to know that there are more deaths from inflammation of the lungs in winter, and more from diarrhœa in the summer,—we need to know to what condition of the air, what condition of the body, or of its surroundings, the increase of deaths or of sickness is due, before we can consider the best methods for changing or for avoiding those conditions.

Only by long-continued watching, recording, and studying the meteorological conditions can we learn whether it is the cold, the absence of moisture, the excess of ozone, or the action of the wind, which causes so many more deaths from diseases of the throat and air-passages in winter than in summer, or whether all these are but indirectly related to the subject and the real cause is—as Dr. A. N. Bell has recently suggested—filth, which can easily be removed or avoided. Yet nothing is more certain than that if systematic effort is made we can learn which of the conditions are invariably coincident with the disease and which are only incidentally present; for notwithstanding the fact that in this State the air is generally cold, dry, windy, and contains an excess of ozone in winter, these conditions do not prevail with absolute uniformity, but sometimes one is absent and sometimes another, therefore sooner or later every one of these and other conditions can be compared with the sickness and the deaths from each of the different diseases which now afflict us, and the truth learned as to whether these relations severally or collectively are those of cause and effect. If individual effort could readily achieve this, I think it would have been done long ago; but when the people of a State collect, compile, and publish the material essential for such studies the work has begun, and in this State such a beginning has been made. From the earliest times it has been known that the weather has much to do with health, but at the time the first State report on vital statistics in Michigan was published (for 1867) the compiler gave only a single table of results of meteorological observations, at the Agricultural College, and regretted his inability to secure results of any other observations in the State. It is only within a few years that systematic observations have been taken for the public-health service of the State, and even now no compensation is given for such important service; but philanthropic persons are now prompted to contribute their labours because the State will compile and publish, and thus render their work available for use in sanitary science.

The State Board of Health now receives contributions of meteorological records from about thirty observers in different parts of the State. Each observer makes records of observations three times each day, namely, at 7 a.m., 2 p.m., and 9 p.m.; and he records the facts relative to temperature, humidity, barometric pressure, clouds, winds, ozone, rain, and snow. As these observers "work for nothing and board themselves," they are not expected to add the figures in the several columns for the months; such labours and also computations of the absolute and the relative humidity, computations to learn the actual pressure of the atmosphere, etc., are performed in the office of the State Board at Lansing, where also tri-daily observations are taken. The reports of these thirty or more observers, when added, computed, and averaged, are compiled in tables, showing for each locality the average for each meteorological condition which is observed. These tables may be used for purposes of study by any person. In order, however, to prepare in the best manner possible the statements of the conditions of the air, so that they may most easily be compared with statements of the sickness or deaths from each disease, and an estimate made of the influence upon the disease by each meteorological condition, it has been the custom to so perfect the data that it can be represented to the eye on a diagram drawn accurately to scale. Such diagrams are as useful and as essential to the sanitarian as are the profiles which the surveyor makes for "cuts" and "fills" to the builders of railroads and streets, and their modes of construction and use are similar.

SPECIAL INVESTIGATIONS.

Sanitarians must do more than utilize contributions from meteorology and from

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each of the other sciences; they must make original investigations, such as will result in the actual creation of knowledge never before attained; this is the grand mission of sanitary science in behalf of human welfare, and for this sanitarians must face up to nature in ways never before attempted by human beings, and must bring back from this search after revelations, portions of that eternal truth which will teach us the way of life, the way of health, and the way of happiness.

What some of the points are concerning which special investigations are needed, it may not be amiss to say a word here. With regard to small-pox, diphtheria, and scarlet fever, three dreaded diseases which afflict our people, the State Board of Health, in common with the leading men of the medical profession generally throughout the State, already know enough to suppress these diseases if the people could be put in possession of the knowledge and would act upon the information, which however is not likely to be placed before them unless the State Board of Health can have the means for this important service. In fact, small-pox is practically suppressed in Michigan to-day, and diphtheria and scarlet fever have, in many instances in this State, been stamped out of existence in localities where they have appeared. The way to control scarlet fever or diphtheria is not, as seems to be the opinion of many intelligent people and some physicians even, to wait till the disease has taken possession of an individual and then do something to him to kill the disease, provided that the disease does not first kill him, but to keep the disease out of him from the first, by keeping it away from him and him away from it; and to shut the disease into the closest possible quarters and then burn it out or smother it in its most secret lurking-places. This is possible, it is practicable and when all our people join hands to do it, it will be as easy as it is now to keep the wild bears of the forest from our homes; but without efficient local boards of health, and general coöperation by the people, no family can protect itself from either scarlet fever or diphtheria.

With regard to diphtheria, however, there are questions which it would be of use to have decided. We know that the living germs or the poisonous elements which cause the disease are reproduced within the human body, and that in various ways, direct and indirect, the disease is communicated from one person to another; in other words, we know that the disease is *contagious*; whether it is also *infectious*, that is, whether the invisible germs or elements of poison whose presence in the body causes the disease are also sometimes reproduced in substances outside the body, how long they can live (or continue efficient to cause disease) in substances outside the human body, and in what substances they can live and retain their deadly power, are questions the correct and unquestioned answers to which would be of great use in preventing the disease and in destroying its cause. It would also be of service to know what it is that makes some epidemics of diphtheria much more malignant than others, for thus we may be able to substitute mild for malignant epidemics, in some such way as is done for small-pox.

We know that the typhoid-fever poison is communicated by water and by milk; but we need investigations to learn in what other ways it may be communicated, and how it is propagated, whether always in the body or sometimes outside the body, and in what lower animals.

There is much, too, that needs to be known concerning consumption, a disease of which more is said in another part of this paper.

The question of the causation of intermittent fever, or fever and ague, as it is called, which we now know to cause more sickness in Michigan than does any other disease, is still an unsettled question; and while much has been done towards preventing it, by drainage, by cultivation of the soil, and by planting of trees, it would be a great boon to the people of this State if we could know certainly what are the relations of intermittent fever to marsh land, or what it is connected with overflowed land that so greatly favours the disease, what are the conditions both subjective and objective under which ague is certain to arise, what is the specific poison of the disease, if such there be.

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CLIMATIC DISEASES MAY BE CONTROLLED OR AVOIDED.

With increasing facilities for travel it may soon be practicable for human beings to gain as much control over their climatic conditions as the wild geese have so long enjoyed; but before this can be realized we must know as much as the geese do,—for they seem to have gained that knowledge which mankind are so slow in gaining, and for the attainment of which I am pleading, namely such knowledge as will enable any person to know the special danger at each age and at each season of the year in each habitable portion of the earth. But, because of the expenses of travel and the many difficulties in the way of periodical movements of the population, I would not be content to stop with the knowledge of a wild goose. There *are* animals which know enough to take care of themselves in warm or in cold seasons of the year, particularly in climates so favorable as that in Michigan; and I see no reason why men may not eventually learn to do as well, if only they will admit the feasibility of so doing, and will devote a necessary part of their energies to this undertaking. In order to accomplish it, however, it seems to me essential that there shall be organized effort, and especially that those whom we elect to apportion the expenditures of the State, in the interest of the whole people and not for the exclusive benefit of local or class interests, shall understand the aims and purposes of the systematic study of the causes of sickness and deaths, and shall recognize those purposes as high and noble.

I hope no one will infer that in this paper all the work of the State Board of Health is mentioned; in view of the many other labours by the Board, and by individual members of the Board, it is my duty to say that this paper relates only to a small part of the work of the Board, a part which less than many other parts has to do with its every-day work at the present time, such, for instance as the dissemination of information already gained; yet it seems to me that it is work which it is absolutely essential to have done in order that in the future progress in sanitary science and service may be possible; and it cannot be done except by thorough coöperation among several classes of people. The purpose of this paper is, therefore, the hope of creating a greater interest in a subject which I deem of vital importance to our fellow-men.

ANNOUNCEMENTS.

Part III. of the "Scientific Roll" will be commenced, if life and health and support be granted to the Conductor, in 1883. In order that the Bibliography may be as full as possible, authors and publishers are respectfully solicited to send copies of, or references to, all their publications dealing with the barometrical condition of the air.

As soon as 200 persons have expressed a wish to subscribe for any one of the subjects mentioned below, the publication of that section of the "Scientific Roll" will be forthwith commenced. The subscription price will be 7*s.* 6*d.* and 10*s.* for each volume, according as the residence of the subscriber is at home or abroad. Each volume will comprise from 400 to 500 pages; and each volume will, in most cases, contain two or more parts, each of which may be subscribed for separately. The extent of these parts will depend upon the amount of matter in hand, so that the subscription price for each cannot be fixed at present, but will be settled when the publication of each part is commenced. The following is a list of the principal subjects:—

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THE SCIENTIFIC ROLL.

main purposes of this Magazine are to facilitate research, and to afford a ium by means of which Scientific enquirers may help each other.

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Each Science which is considered will be subdivided into a number of Sections, each such Section will have a Part of the Magazine devoted to it. This enable persons who wish for information on a limited range of subjects to hase the portion of the Magazine relating to it at a small cost.

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t I. GENERAL.
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IV. CARBONIC ACID AND CHEMICAL RAYS.
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„ VIII. LUMINOUS RAYS.
„ IX. MIASMA.
„ X. OZONE.
„ XI. RAINFALL.
„ XII. SNOWFALL.
„ XIII. TEMPERATURE.
„ XIV. WIND.

Each of these Parts will relate to the subject generally. The Parts following e will deal with the Climate of each country.

It should be borne in mind that Climate only is dealt with in these Parts, so persons wishing for information as to the physical and other properties of eous Vapour or of the Structure of a Hailstone, or as to how a Barometer is ed, may not find anything, because the proper place for such details is under r Sections of the "Scientific Roll." Thus all the details relating to Aqueous our which are not climatic will be found in the Section which will be devoted ater, should the "Scientific Roll" reach that stage. Again, the formation of ometers, and other Meteorological Instruments, have their place in the classifica- here adopted under Man.

The Meteorological Section of the "Scientific Roll" is, then, not an isolated ment, but the principles upon which it is conducted are based upon a classifica- which has been applied to all the Natural History Sciences. The Systematized s Scheme is not a mere crude proposal, but it is one that has already been tically applied over a very large field of knowledge.

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THE

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AND

Magazine of Systematized Notes.

CONDUCTED BY

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CLIMATE.

VOL. I.

Let there be truth and let there be order: for truth and order regulate all things in the realm of nature, and the laws of nature are the visible expression of the active thoughts of God.

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Lamont, Prof. *Proc. Brit. Meteor. Soc.*, vol. i. (No. 6, published Jan. 21, 1863.) Translated by W. T. Lynn. From *Phil. Mag.*, Nov. 1862 (*rv*).

(*Page* 311.) We are now arrived at a point in meteorology where it is absolutely necessary to come to a definite decision as to what is the relation in which the aqueous vapour existing in the atmosphere stands to the atmosphere itself. Does the aqueous vapour form an atmosphere itself, independent of the air; or is it merely mechanically mixed with the air, so as only, as a gas standing in mechanical relation to the air, to increase the volume and the weight of the atmosphere? I think I have arrived at a decisive result—one which is opposed to the generally prevailing views of physical geographers and meteorologists. Nothing of importance has been added to Dalton's theory of the action of aqueous vapour by later investigators. Dalton's experiments tend to the following results :—1. In space destitute of air the evaporation of water goes on only until the vapour has attained a determinate expansive force, dependent on the temperature; so that in every space void of air which is saturated with vapour a determinate vapour pressure corresponds to a determinate temperature. 2. In space filled with air the same (*Page* 312) amount of water evaporates as in space destitute of air; and precisely the same relation subsists between the temperature and the expansive force, whether the space contains air or not. 3. The evaporation of water goes on rapidly in space devoid of air, but very slowly in space filled with air in a state of quiescence; and even when it is assisted by a tolerably brisk motion of the air a considerable time is notwithstanding always required. In this way are the development and extent of aqueous vapour, in space void of air and space filled with air, determined by means of Dalton's experiments; as to the mutual relations subsisting between vapour and air, when they are simultaneously present in the same space, the experiments afford no information; and this deficiency Dalton supplied by giving to the second of the above-quoted propositions such an interpretation as if no mutual relations existed between vapour and air, and as if they remained near each other without producing the slightest mechanical effect upon one another. It is strange that philosophers have accepted this theory without remarking that it constitutes only a possible result of the experiments; and that meteorologists have treated it as available for application to the aqueous vapour of the atmosphere, and have supposed an atmosphere of vapour to exist independent of the air, notwithstanding that the third of the above propositions properly declares that there is indeed always a tendency to a normal relation, which is conceived to be in a state of restoration, but which is never reached, because, in consequence of the changes constantly taking place, the requisite time to produce an equalisation is never afforded. Objections have from time to time been brought forward to the existence of an atmosphere of vapour independently subsisting. Bessel has ('Astr. Nachr.,' No. 236) adduced the consideration that in such a vapour atmosphere the expansive force of the strata incumbent upon one another must diminish according to a certain proportion, but that from different observations it may be concluded that this proportion does not really exist. The experiments of Broun in Makerstoun (Report to Sir T. Brisbane) and Jelinek in Prague ('Denk. Wien. Akad.,' vol. ii.) proved that in different localities situated very near together, where the same reading of the barometer is observed, a very different vapour-pressure may be indicated. Espy opposed the theory, and exposed its defects, without furnishing a precise refutation. I believe I first brought forward a proof of its incorrectness in 1857, when I showed (*Page* 313) by means of observations extending through many years, that in a small vapour-pressure the mean reading of the barometer stands quite as high as in a great vapour-pressure; at the same time I contrived an easily-performed experiment in which, contrary to Dalton's theory, a mass of vapour and a mass of air placed in communication with each other mutually preserve a state of equilibrium without

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the vapour penetrating into the air or the air into the vapour. As the result of this I laid down the proposition that the vapour exerts a pressure upon the air and the air upon the vapour; and that the atmosphere is to be regarded as a mixture of masses of air, some more and some less humid. Strachey furnished a second very strong proof of the inadmissibility of Dalton's theory in a paper read to the Royal Society in 1861. Proceeding upon considerations which are fundamentally identical with those developed by Bessel, he gave a collection of the results of observations which had been obtained upon high mountains and in air balloon expeditions, and showed that they were incompatible with the supposition of an independently subsisting atmosphere of vapour. To instance one point only, it may be here mentioned that the observations of Walsh, who ascended in a balloon to the height of 23,000 feet, place us in a position to calculate the pressure which the vapour contained in the atmosphere would exert upon the earth's surface; but the value determined in this manner amounts only to the fourth part of the pressure actually assigned by the psychrometer. Nevertheless we find in the most recent times that the pressure of the dry air and the pressure of the vapour atmosphere are kept distinct. The only way of removing the rooted ideas based on Dalton's laws is to prove that these laws themselves contain an essential error. Air and vapour spread into each other with extreme slowness; it is mainly the circulation of air that carries off the vapour from the evaporating surface; one would almost believe that the individual molecule of air must come to the surface of the water to take thence the moisture, and to the chloride of calcium to give up to it the moisture; the expansive force of the vapour itself is in every case a matter of small influence on its diffusion in the air. Now, if we take a closed tube ABCD, fig. 1, filled with air, and introduce a small quantity of water through an aperture near A, which is immediately afterwards closed, into the bottom AB of the tube, the water begins gradually to evaporate, and the vapour ascends after the expiration of a certain time up to *ab*. How then will the pressure be distributed upon the interior sides of the tubes? If the vapour and air exert a mutual pressure upon one another, the expansive forces of the air and of the vapour will act together in such a manner that an amount equal to their sum will press upon all points of the interior wall; and if we take separately the pressure peculiar to the vapour alone, it is precisely as great as if the mass of vapour was uniformly distributed in the whole space ABCD. A totally different state of things will result if the view set up by Dalton is well founded; for as, according to this view, the vapour diffuses itself in the interstices of the molecules of air without producing any mechanical effect upon the molecules themselves, no pressure at all can be produced upon the interior side of the tube by the expansive force of the vapour under the circumstances indicated above, and no pressure takes place until the vapour reaches the upper surface CD. The state of things here indicated is only a transitory one; a similar state may, however, be made permanent by maintaining in the lower space AB*ab* a higher and in the upper space *ab*CD a lower temperature. If we denote the lower space by V, the upper by V', the lower temperature by t, the higher by t', and the corresponding expansive forces of the vapour by $f(t)$ and $f(t')$; also the expansive forces of the enclosed masses of air by $k(1+at)$ and $k(1+at')$, we have, according to the hypothesis advocated by me, the expansive force of the mixture

fig. 1.

$$= \frac{V}{V+V}\left[k(1+at)+f(t)\right] + \frac{V'}{V+V'}\left[k(1+at')+f(t')\right]$$
$$= k + \frac{ka}{V+V'}\left(Vt + V't' + \frac{1}{V+V'}(Vf(t)+V'f(t'))\right);$$

whereas, according to Dalton's theory the expansive force will only amount to

$$k + \frac{ka}{V+V'}(Vt+Vt') + f(t');$$

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while the vapour passing into the space *ab*CD with the force $(t) + f(t)$ must be immediately condensed. Thence it immediately follows that if the temperature t' of the upper space remains constant, while the temperature of the lower space gradually increases, the pressure upon the upper surface CD is increased, according to Dalton's theory, only by the expansion of the air, but not by the newly forming vapour itself; whereas, according to my hypothesis, besides the effect which is produced by the expansion of the air, a very considerable augmen- (*Page* 315) tation of the pressure arises from the newly-formed vapour. As we can imitate these conditions, we have a simple means of deciding as to the correctness of Dalton's theory. I selected the following experiment:—A glass tube, bent in the form represented in Fig. 2, was provided at one end with a globe K, whilst the other end *e* was left open; in the straight part *de* it was made to contain a drop of quicksilver *q*. The curved part *ckd* of the tube was plunged into a vessel BB filled with clear water; into the vessel AA, where the globe K was placed, cold and warm water could be poured. The globe K was first filled with dry air, and the experiment showed that if the temperature was increased from 67°·3 to 126° the drop of quicksilver moved forwards by 12·224 in. During this experiment a thermometer placed in the vessel BB stood at 59°. Afterwards the globe was opened by breaking off the fine point *a*, some water introduced, and the point again joined on by melting. Again cold and warm water

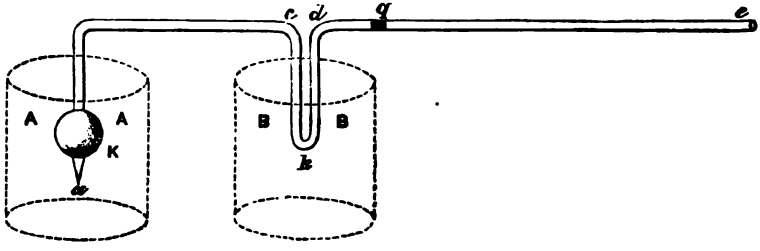

Fig. 2.

were poured into the vessel AA, while the temperature of the tube remained unaltered, by which means, according to the theory of Dalton, a rise of temperature from 67°·3 to 126° would, if the vapour had not penetrated in the tube up to the drop of quicksilver, move the latter, as before, 12·224 in., and if the vapour had so penetrated, at the most $\frac{1}{18}$th further; instead of which the motion actually produced amounted to nearly the double of this. It resulted from accurate measurement that the 12·224 in. were passed over as soon as the temperature had been raised from 67°·3 to 101°·5. A second glass tube was employed of a similar form, but with a smaller globe, and with this, as long as there was only dry air in the globe, an increase of temperature from 64°·4 to 131°·5 occasioned in the drop of quicksilver a motion of 13·706 in.; but after a small quantity of water had been introduced into the globe, the quicksilver moved the same distance when the temperature was raised only from 64°·4 to 102°. As it might be imagined that it was possible that after a longer interval of time the vapour would extend up to the drop of quicksilver and then produce (*Page* 316) a different result, the globe was left for a whole hour in warm water, but the position of the water remained unchanged. Also, after the termination of the experiment, neither in the first nor in the second tube could a trace be perceived of the vapour having passed down into the bent part between *c* and *d*, so that it probably penetrated into the tubes not at all, or only to a small extent.

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On this supposition the observed effect would require the conclusion that the increase in the expansive force of the dry air in a change of temperature from 67°·3 to 126° is precisely as great as the increase in the expansive force of the air and the aqueous vapour in a change of temperature from 67°·3 to 101°·5; and this also agrees exactly, for the former increase is calculated to be ·119, and the latter amounts to—

For the air	0·070
For the vapour	0·048
Therefore, together	0·118

In the second experiment we have the increase of the expansive force—

For dry air from 64°·4 to 131°·5	0·076
For vapour „ „	0·052
Therefore, together	0·128

little differing from the preceding number. I repeated the experiment in a modified (*Page* 317) form, calculated to give more accuracy. The result was substantially the same. The conclusion is, that the air exerts a pressure upon the vapour, and the vapour upon the air. I hope at a future opportunity to show that the humidity must be regarded as adhering to the molecules of air, and that the phenomena admit of a simple explanation by means of a natural hypothesis concerning the expansion of dry and wet molecules of air. If it be desired to apply the above to the circumstances of the aqueous vapour in the atmosphere, it is in the first place to be inferred from that (since the diffusion of the vapour in the air takes place (*Page* 318) but very slowly, and since in different places, according to the temperature and the magnitude of the surface of water exposed to the air, very different quantities of vapour pass into it), in regard to the humidity of the air, strictly speaking, no relations subsist conformable to any law. Of course the continually existing currents of air occasion a complete mingling of the more or less dry masses of air; but this takes place in no uniform manner, and therefore no exact relation of dependence exists between the degrees of humidity in different points of any space. But particularly the idea of an atmosphere of vapour subsisting independently by itself appears to be inadmissible, and the data furnished by the psychrometer can no longer be regarded in any other light than as the expression of local humidity.

Speke, J. H. *Journ. Roy. Geog. Soc.*, vol. xxxiii. (1863) (*rs*).

(*Page* 333.) In Africa, beyond 3° lat. both north and south, the land is subject to continual droughts for five, six, or more months in the year, which last systematically longer as the distance increases from the equatorial zone. The rain follows the sun, and the opposite region is dry.

1864.

Buchan, A. (*B.* 1864, 1.)

Monthly means will not serve for ascertaining when are the periods the clouds begin to disperse and when brighter skies take their place. In Scotland [and no (*Page* 9) doubt in other places under like conditions] the highest temperature occurs in the broad plains, particularly those which are bounded on the south-west by high and extensive ranges of hills, which by more effectually draining the south-west winds of their moisture, clear the skies of clouds, and thus allow freer passage to (*Page* 137) the sun's rays. When the air is clear and transparent, but loaded with much moisture in an invisible state—in other words, when the dew-point is high—the invisible particles of water offer a powerful obstruction to the free passage of the caloric of radiation, in much the same way as stones in the channel of a river oppose

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its course; so that in a moist though perfectly clear atmosphere the process of radiation proceeds at a very slow rate. Let, on the contrary, all or nearly all the vapour be drained out of the air, the escape of heat from the earth's surface by radiation would then be so swift and great that the temperature would fall low (*Page* 149) enough to destroy life. For turnips the weather should be mild and dry, during the middle of May [Scotland being the country specially alluded to] to the middle of June, when they are sown; moisture and warmth are required in their brairding, and their growth towards the time for singling. At singling and after-growth the weather should be dry and warm. These include the second half of June and most of July. From July to October the weather should be showery at intervals. For cereals, the sowing month of March for oats, and April and half of May for barley, should be cool and dry. In the after-growth of wheat, barley, and oats, till the blooming season in July, the weather should be dropping and warm. The blooming season in July should be dry, warm, and calm. After that, till within a month of harvest, at the end of August or beginning of September, there should be showers and warmth. During the period from that to and after harvest it should be dry and hot.

1865.

Becquerel, A. C. (*B.* 1865, 1.)

[The name is misprinted Becqueral in the place cited. The paper is translated from 'Comptes Rendus,' lx. p. 136.] The influence of forests on climate depends (*Page* 235) in part on the process of evaporation possessed by the leaves. Evaporation from the leaves is a constant and active cause of humidity, which a little lowering of the temperature condenses into vapour [as the translation has it]; and the water which is thus produced tends to keep the soil moist. The effect which the (*Page* 236) cutting down of forests has on the sources and volumes of the rivers which water a country is too important an element to be lost sight of. The difficulty of discovering the causes of these effects is sometimes so great that we could not predict whether a particular spring or river would be increased by cutting down a forest and bringing the soil under cultivation. Forests contribute to the sources, not only by the humidity they cause and the condensation of vapour which accompanies it, but also by the obstruction they offer to evaporation from the soil; and it may be remarked that the roots of the trees, by breaking up the soil, render it more (*Page* 237) porous, and thus facilitate the process of infiltration. In considering the important question of the influence which the cutting down of woods has on springs and rivers we arrive at the following conclusions:—1. Extensive clearings of wood lessen the volume of the rivers which water a country. We are not yet able to decide if this diminution is to be attributed to a less quantity of rain falling annually or to a more active evaporation, to both causes combined, or to a different distribution of the rainfall. 2. Cultivation carried on in a dry and rainless region lessens the amount of spring-water. 3. In countries which have not undergone any change in the amount of land under cultivation the quantity of spring-water appears to be always the same. 4. Forests, in the better protection they afford to springs, husband the water and regulate its flow. 5. The humidity is increased by forests, and the roots of trees render the soil more pervious to the rain-water. 6. Clearings in mountainous countries exercise an influence on the sources of the water supply and on the rivers.

Buchan, A. (*B.* 1865, 4.)

(*Page* 200.) From the observations collected [on the storms of Europe towards the end of 1863] we learn that as long as the barometer did not fall below the mean there was no continuous rain anywhere; but blue sky, varied with sky partially clouded or with fog, prevailed. When, however, the barometer fell in the

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west, the sky began to be obscured and showers to fall at intervals. When the centre of the storm had passed, or the barometer had begun to rise, the rain became less heavy, the clouds began to break up, and fine weather, ushered in with (*Page* 228) cold breezes, ultimately prevailed. Oats require a lower temperature (*Page* 229) and more moisture to bring them to perfection than wheat or barley. (*Page* 230) The greatest number of victims to consumption [in Scotland in 1864], and perhaps also brain diseases, occur in spring, when the air is driest; and the least number in October and November, when the humidity of the air is greatest.

Forbes, C. *Journ. Roy. Geog. Soc.*, vol. xxxiv. (1865) (*rsp*).

(*Page* 157.) In Vancouver Island the ordinary course of the seasons is as follows. After the gales with rain, which generally mark the period of the equinox, fine clear weather sets in, and continues till about the middle of November. Then the rains set in.

Palgrave, W. G. *Journ. Roy. Geog. Soc.*, vol. xxxiv. (1865) (*rsp*).

(*Page* 136.) In the Nejed between March and November the fine weather is uniformly clear and dry.

Watts, H. (*B.* 1865, 14.)

(*Page* 100.) The action of the sun upon the water at the surface of the earth causes a natural process of distillation upon an enormous scale to be always going on. The water evaporated from the earth's surface rises in the air as vapour, and being afterwards deprived of its heat of vaporization, partly by radiation into space, and partly by contact with mountain-summits or with the cold air existing at high elevations, returns to the earth in the various forms of dew, mist, rain, snow, hail, etc. In this way an immense quantity of water is being continually lifted from the sea-level, a large portion of which does not fall again directly into the sea, but being deposited on elevated portions of the land, becomes the mechanical source whence rivers and streams are supplied. The watery vapour which reaches the higher and colder regions of the atmosphere is there condensed into snow. This, as it falls again towards the earth, returns to the condition of water, if the air is sufficiently warm to liquefy it; but part of it reaches the earth unmelted, and that which falls upon regions whose temperature is below 0° C. accumulates to form the masses of ice known as glaciers.

1866.

Buchan, A. (*B.* 1866, 2.)

(*Page* 352.) [Since the bibliography was published the facts have been entered from an earlier source, so that this bibliographical reference should be cancelled.]

Home, D. Milne. (*B.* 1866, 5.)

(*Page* 330.) Evaporation will take place much more rapidly from a soil that is bare, or partially so, than from a soil that is well clothed with grass. I filled two zinc boxes with sandy loam and with strong clay, and adjusted them on a balance. Into each the same quantity of water was put. The thermometer in the sandy loam was lowest, and in less than a week this box rose above the other with clay, in consequence, I suppose, of more water having been evaporated from it.

Mitchell, A. (*B.* 1866, 10.)

(*Page* 303.) Little ragged clouds, something resembling uncut horsetails, are called 'fillie-tails,' and forebode windy weather when they seem to come from the south—

When frae the south whusk fillie-tails,
Then high ships wear low sails.
(Galloway.)

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Noah's Ark.—In the winter season—for the ark is not common in any other—when the sky is clear and the weather frosty, curious light grey clouds, in the shape of ribs, will oft arise from a point in the horizon, and stretch over the sky to its opposite point on the other side. These cloudy ribs narrow in bulk towards the horizon, and are at the widest right over our heads, or in the zenith. In this form (*Page* 304) it will appear for a day together or even longer. What is singular, too, is we have no half-arks; the one half never sinks below the horizon, and leaves the other half alone. We have it as if it were calculated to appear in our latitude and longitude; for it begins to form, comes to perfection, and vanishes away all in our canopy. When seen in frosty weather—and it generally is—weather-wise folk prognosticate a thaw, instantly attended 'wi' an awful spate.' The ark is a great thaw sign. The ark is not always regarded as a forerunner of bad weather. When it runs north and south, the aftercome is not so much dreaded as when it is stretched between any of the other points. (Galloway.)

(*Page* 305.) Clear to the south will drown a ploughman. (Berwickshire.)

Grumphie smells the weather,
And grumphie sees the wun',
He kens when cluds will gather
And smoors the blinking sun.
(Galloway.)
[? Should it not be smoor,]

Semenof. *Journ. Roy. Geog. Soc.*, vol. xxxv. (1866) (*rsp*).

(*Page* 226.) Dry atmosphere has the effect of raising the snow-line. Hence the elevation of this line above the normal altitude for the latitude indicates a dry air. (*Page* 227) Rhododendrons mark a moist atmosphere.

Temple, R. *Journ. Roy. Geog. Soc.*, vol. xxxv. (1866) (*rsp*).

(*Page* 71.) On the plateau of Chutteesgurh the soil is so moist that the sugar cane can be grown without irrigation. It is itself destitute of wood, but is surrounded by forests.

Wilson, J. Fox. *Journ. Roy. Geog. Soc.*, vol. xxxv. (1866) (*rsp*).

(*Page* 113.) During the year 1862 a severe drought prevailed throughout Cape (*Page* 114) Colony and South Africa. Livingstone refers to the dry season in the Bakwain country, and mentions, as indicative of the dryness of the air, that needles lying out of doors for months did not rust; that a mixture of sulphuric acid and water parted with its water to the air; that the leaves of indigenous plants were drooping, soft and shrivelled; and that the leaves of mimosæ were closed by day as well as by night.

1867.

Blackmore, R. D. *Symons's Meteorol. Mag.*, vol. ii. (1867) (*rsp*).

(*Page* 81.) Teddington. On the evening of July 24th there was noticed a very peculiar appearance in the south-east after sunset. The sky was chiefly overcast with a free display of red streamers all over the east and south; but in the south-east was a beautiful fan of blue divergent radii, rising 30° above the horizon, and breaking across the redness like a windmill with blue sails. On the night of the 25th there was a tremendous downpour of rain.

Brumham, G. D. *Symons's Meteorol. Mag.*, vol. ii. (1867) (*rsp*).

(*Page* 40.) [He conjectures that there may be a 29-year period in meteorology,

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and he extracts from Whistlecraft's works all the cases that appear to indicate this. Those only are given here which refer to dry weather.]

1746. An exceedingly hot and dry summer.
1747. Dry season.
1759. A hot summer and dry.
1760. Very hot and dry summer.
1762. A very hot and dry summer, and a very dry year.
1765. A very dry summer, and often very hot.
1771. A very dry summer and year.

1775. A hot and dry summer.
1776. Chiefly dry and fine from May. (*Page* 41.)
1781. A hot, dry summer.
1793. Intensely hot and dry part of summer.
1802. Hot and dry two months of the summer (August and September).
1818. A remarkably dry and hot summer.
1819. A hot and dry summer.
1822. Great heat and drought part of summer. Very fine till October.
1834. Sharp drought in spring and greater part of summer, and generally very hot.
1835. A very hot and dry summer, and very great drought in July and August.

1775. Summer dry and hot.
1776. Chiefly dry and fine from June.
1788. A hot summer and dry year.
1789. Rather wet summer.
1791. A very hot and dry summer, and a very dry year.
1794. Rather a dry summer and very hot from June 12th to July 18th.
1800. Excessive drought from June 22nd to August 19th.
1804. Extremely hot and dry in September.
1805. Very hot.

1810. A dry year to October.
1822. Great heat and drought part of summer.
1831. Hot and dry two months of the summer (July and August).
1847. A remarkably dry and hot summer.
1848. A wet summer.
1851. Great heat and drought part of summer. Very fine till end of October.
1863. Sharp drought in spring and summer, and generally very hot.
1864. A very hot and dry summer, and very great in July and August.

1867.

Buchan, A. (*B.* 1867, 3.)

(*Page* 3.) The hygrometer is an instrument of great value in meteorology, (*Page* 4) as indicating the quantity of vapour in the air, and inferentially the changes of weather depending thereon. De Saussure may be considered the founder of this department of meteorology by his researches. Pictet made valuable observations on dew. Patrick Wilson missed the point of the argument in continuing (*Page* 5) to entertain the notion that the cold accompanying dew was after, instead of before, its deposition. Dr. Wells collected the observations into a coherent whole, and accounted for them by his theory of dew, which all succeeding inquiry has confirmed. His 'Theory of Dew,' published in 1814, must always be regarded as one of the greatest contributions made to meteorology. Dr. Wells made the discovery that during those nights when dew is deposited, the temperature of bodies on the earth's surface is colder than that of the surrounding air. In 1823, Daniell discussed in his 'Meteorological Essays' the hygrometry of the atmosphere and evaporation. Hygrometry is indebted to him more than to any other philosopher. The law of the diffusion of vapour through the air, its influence on the barometric pressure, and its relation to the other constituents of the atmosphere, are among the least satisfactorily determined questions in meteorology. Since this element is so important as an indicator of storm and other changes of the weather, it is to be hoped it will soon be more thoroughly investigated. A most important addition to our knowledge of the atmosphere was made in 1862 by Prof. Tyndall, in his (*Page* 6) experiments on radiant heat, especially as regards the gases, by which it is shown that the vapour of water exerts extraordinary energy as a radiant and absorbent of heat. It is to be expected that the relations of atmospheric vapour will soon be turned to account in explaining many questions of meteorological (*Page* 24) inquiry. The barometer is influenced to a large extent by the elastic force of the vapour of water, invisibly suspended in the atmosphere, in the same way as it is influenced by the dry air. But the vapour of water also exerts a

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pressure on the barometer in another way. Vapour tends to diffuse itself equally through the air; but as the particles of air offer an obstruction to the watery particles, about 9 or 10 a.m., when evaporation is most rapid, the vapour is accumulated or pent up in the lowest stratum of the atmosphere, and being impeded in its ascent, its elastic force is increased by the reaction, and the barometer consequently rises. When the air falls below the temperature of the dew point, part of the vapour is deposited in dew, and since some time must elapse before the vapour of the upper strata can diffuse itself downwards to supply the deficiency, the barometer falls most rapidly at 10 p.m., when the deposition of dew is greatest. As regards vapour in the atmosphere, the barometer is subject to two maxima and minima of pressure—the maxima occurring at 10 a.m., when, owing to rapid evaporation, the accumulation of vapour near the surface is greatest, and about sunset, or just before dew begins to be deposited, when the relative amount of vapour is greatest; and the minima in the evening, when the deposition of dew is greatest, and before sunrise, when evaporation and the quantity of vapour in the air is least. Thus the maximum in the forenoon is brought about by the rapid evaporation arising from the dryness of the air, and the increasing temperature. But as the vapour becomes more equally diffused, and the air more saturated, evaporation proceeds more languidly; the air becomes more expanded by the heat, and flows away to meet the diurnal wave of cold advancing from the eastward. Thus the pressure falls to the afternoon minimum about 4 p.m. From this time the temperature declines, the air approaches more nearly the point of saturation, and the pressure being further increased by accession of air from the warm wave now considerably to the westward, the evening maximum is attained. As the deposition of dew proceeds, the air becomes drier, the elastic pressure of the vapour is greatly diminished, and the pressure falls to a second minimum about (*Page* 25) 4 a.m. The amount of these daily variations diminishes from the equator towards either pole, for the obvious reason that they depend, directly or indirectly, on the heating power of the sun's rays. Thus, while at the equator the daily fluctuation is 0·125 in., in Great Britain it is only a sixth part of that amount. It is very small in the high latitudes of St. Petersburg and Bossekop; and in still higher latitudes at that period of the year when there is no alternation of day and night, the diurnal variation probably does not occur. In the dry climate of Barnaul, in Siberia, there is no evening maximum; the lowest minimum occurs as early as midnight, and the only maximum at 9 a.m. So far as the dry air of the atmosphere is concerned, the atmospheric pressure will be least in the summer and greatest in the winter of each hemisphere [warm and cold hemispheres north and south]. But the production of aqueous vapour by evaporation being most active in summer, the barometer will be much increased from this cause. As the aqueous vapour is transferred to the colder hemisphere it will be there condensed into rain, and being thereby withdrawn from the atmosphere, the barometer pressure will be diminished, but the dry air which the vapour brought with it from the warm (*Page* 26) hemisphere will remain, thus tending to increase the pressure. The barometer is high at Calcutta in January, owing to the dry, cold, dense air of Central Asia being conveyed southward over India. At places where the amount of vapour in the air varies little from month to month, but the variations of temperature are great, the differences between the summer and winter pressures are very striking. Thus, at Barnaul and Irkutsk, both in Siberia, the pressures in July are respectively 29·243 and 28·267, and in January 29·897 and 28·865, the differences being upwards of six-tenths of an inch. The great heat of summer in Siberia causes the air to expand and flow away in all directions, and the diminished pressure is not compensated for by any material accession being made to the aqueous vapour of the atmosphere; and, on the other hand, the great cold and

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little rain in that region during winter causes high pressures to prevail during that season. The same peculiarity is seen, though in a modified degree, at St. Petersburg, Moscow, and Vienna. At Reykjavik, in Iceland, the pressure in June is 29·717, and in December 29·273; at Sandwich [=Sandwick], Orkney, 29·775 and 29·586; and at Sitcha [=Sitka], in Russian America, 29·975 and 29·664. In all these places the distribution is just the reverse of what obtains in Siberia, being least in winter and greatest in summer. The high summer pressures are due to the cool summer temperature as compared with surrounding countries; thus causing an inflow from these regions; and to the large amount of vapour in the atmosphere, thus still further raising the barometric column. On the other hand, the low winter pressures are due to the high winter temperatures, causing an outflow toward adjoining countries, and the large winter rainfall, which sets free great quantities of latent heat. The variations in mean pressure are very slight, and not marked by any decided regularity in their march through the seasons, at Dublin, Glasgow, London, Paris, and Rome. As compared with Barnaul and Reykjavik, their temperature is at no season very different from that of surrounding countries, and the rainfall and vapour are at no time much in excess or defect, but are more equally (*Page* 48) distributed over the different months of the year. The temperature of plants exposed to the sun's rays is not so high as that of the soil under the same circumstances, partly because a portion of the solar heat is lost in the process of evaporation from the pores of the plants. Evaporation goes on slowly from damp ground under the trees, being screened by them from the sun's heat. But since the air among the trees is little agitated or put into circulation by the wind, the vapour which arises from the soil is mostly left to accumulate above it. Hence, though exact observations are wanting to settle the question, it is probable that forests diminish the evaporation and increase the humidity. It is not deposited in cloudy weather because the clouds obstruct the escape of heat by radiation into space; nor in windy weather, because wind constantly renews the air in contact with the ground, and thus prevents the temperature from falling sufficiently low. No dew is deposited on the surface of deep water, because its temperature scarcely ever falls below the dew point. When the temperature is below the freezing point the dew (*Page* 68) freezes as it is deposited, and hoar frost is produced. The specific gravity of the ocean is high where the evaporation is great, as in the region of the trade (*Page* 74) winds. The equatorial current [wind] losing heat as it proceeds on its (*Page* 75) course is thereby brought nearer the point of saturation, and consequently becomes a moister wind; while the polar current, gaining heat in its progress towards the equator, becomes a drier wind. The chief effect mountain ranges have on temperature is to drain the winds which cross them of their moisture, and thus to cause colder winters and hotter summers in places to the leeward, as compared with places to the windward, by more fully exposing them to both solar and terrestrial radiations. The western parts of the continents in the north temperate zone are protected from extreme cold by their moist atmosphere and clouded skies. But in the interior of continents it is otherwise; for the winds getting colder and drier as they advance the soil is exposed to the full effects of radiation during the long (*Page* 76) winter nights. Since the air over continents is drier than on sea shores, (*Page* 80) the heating power of the sun's rays is very great during the long days of summer. The quantity of aqueous vapour in the atmosphere is by the processes of evaporation and condensation varying every instant. Vapour diffuses itself through dry air, the presence of dry air having only the effect of retarding the rate of its diffusion. If the vapour of water remained permanently in the atmosphere—that is, was not liable to be withdrawn from it by being condensed into rain—the mixture would be as complete and uniform as that of the oxygen with nitrogen. But the equilibrium of the vapour atmosphere is being constantly disturbed by

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every instance of condensation, by the ceaseless process of evaporation, and by every change of temperature. From these condensations and from the circumstance that the dry air greatly obstructs the free diffusion of the vapour, it follows that the law of the independent pressure of the vapour and of the dry air of the atmosphere does not absolutely hold good, but that from the constant effort of the vapour to attain to a state of equilibrium there is a continual tendency to approach to it. And since the independent and equal diffusion of the dry air and the vapour is owing to disturbing causes never reached, it follows that the observations of the hygrometer only indicate local humidity, and should only be regarded as approximations to a correct indication of the quantity of vapour in the atmosphere over the place of observation. It should, however, be added that, though in exceptional cases the amount of vapour indicated may be wide from the mark, yet in long averages a very close approximation will be obtained. When water evaporates into air the maximum density of the vapour is not acquired till some time has elapsed. (*Page* 83) And since every addition to the vapour increases the pressure, the rate of evaporation is continually diminishing. The amount of evaporation is measured by an evaporimeter, which is usually an evaporating dish about 5 in. in diameter, with an overflow pipe and wirework cover. The best is Mitchell's, which is made on the principle of the fountain inkstand. The advantages are that dew and rain are at once carried away, and that minute quantities can be read off. James Procter Barry's is a modification. The surface is 10 in. square. The small quantity evaporated daily is measured by a scale of brass divided into 10 equal parts placed diagonally in the evaporimeter, so that during the evaporation of one inch of water the line of contact of the surface of the water with the diagonal scale will traverse the whole length of the scale. The $\frac{1}{100}$ of an inch can be easily read. The atmo- (*Page* 84) meter is of some practical use. It is a long glass tube attached to a hollow ball of porous earthenware. The tube is filled previous to observing. There is no class of observations which show such diversity of results as those made by observers of evaporation owing to different methods being employed. The object sought to be obtained is the drying power of the atmosphere. The ocean loses more heat from evaporation than land, because the quantity evaporated from its surface is much greater. Theory should lead us to suppose that the temperature of drained land would be higher than that of undrained, because being drier less heat (*Page* 85) is lost by evaporation. In 1862 the Marquess of Tweeddale offered prizes for sets of observations on this point. Two sets of observations for a year were made, one at Otter House, in Argyle, on arable land, under a rye-grass crop, the soil being light and sandy, and the slope being 1 in 40; the other set at North Esk reservoir, Pentland Hills, on hill pasture, the soil being clay mixed with decayed moss. The following results were drawn. 1. The mean annual temperature of the arable land was raised 8° by drainage, and (2) that of the pasture land, 4°. 3. During sudden falls of temperature and during protracted cold weather, the cold passed more quickly and completely through undrained land than through drained land. 4. When the temperature of the air was higher than that of the soil, drained land received more benefit from the higher temperature than the undrained land, less of its heat being lost by evaporation. 5. Since when rain or sleet fell the superfluous moisture soon flowed away from the drained land, drainage tended to maintain in the soil a comparatively equable temperature; whereas the undrained land was liable to considerable fluctuation, for when soaked with warm rain water its temperature was temporarily raised, and when soaked with melted snow it was temporarily lowered. On one occasion sleet lowered the drained land 2° and the undrained land 4°. 6. The temperature of drained land was in summer occasionally raised above undrained land 3°, and often 2°, and still more frequently 1·5°. Since these different temperatures are chiefly

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caused by the different amounts of water evaporated from the land, it is evident that different results will be obtained from different soils with different crops and with different slopes and exposures. In 1847 Prof. James Elliott made a number of experiments which shed some light on this extensive subject. He found that peat moss can absorb more than twice its own weight of water, dry clay nearly its own weight, dry earth or garden mould more than half its own weight, and dry sand little more than a third of its own weight. With equal times of drying under the same circumstances peat moss lost two-thirds of all the water it contained; clay and earth each more than three-quarters, and sand more than nine-tenths. Evapo- (*Page* 86) ration was greater from the surface of loose earth than from the surface of water, till the earth became so far dry as to be of a light colour. Evaporation from saturated moss was excessive during the first day, being far more than from the surface of water, but on the second day the water began to evaporate most, and on the third day very much more than the moss, although the moss was still wet 10 in. below the surface. From these experiments [those by Dr. Milne Home under 1866 being included] a few practical conclusions may be drawn. In all cases the amount evaporated from wet substances and the consequent decrease of temperature is proportional to the number of evaporating points, or to the whole extent of the evaporating surface in contact with the air. This explains why evaporation is greater from wet moss and grass than from wet soils, and greater from wet soils than from a surface of water. But as evaporation proceeds and the substances begin to dry, the rate of evaporation is modified by the facility with which the water is drawn by capillary attraction from the interior of the substances to their evaporating surfaces. Thus dry sand parts with its moisture sooner than clay, and clay sooner than peat moss. At all temperatures, even the lowest, moisture exists in the atmosphere in an invisible state, so that the air is never (*Page* 87) absolutely dry. Prof. J. D. Everett found that the exact correspondence of the dry and wet bulb thermometers which happens when the air is quite saturated was as rare as eclipses of the sun or moon. The air a few feet above the ground is seldom perfectly saturated. The capacity of the air for moisture increases at a more rapid rate than the temperature. Thus air can contain at 32° the $\frac{1}{160}$ part of its own weight; at 59° the $\frac{1}{80}$; and at 86° the $\frac{1}{40}$; the law being that for every increase of 27° the capacity is doubled. Some hygrometers are formed of substances which readily take up and part with moisture, as Saussure's hair hygrometer. Adie's is made with two pieces of wood glued together. It is of little (*Page* 88) or no scientific value. It is this property of substances to be changed in bulk in attracting moisture or in parting with it, which explains a large number of popular prognostics of the weather, especially such as refer to the feelings and conduct of animals, the opening and closing of flowers, and the lengthening and shortening of strings, cordage, and other materials. Hygrometers constructed on the principle of absorption are faulty, not only because they are irregular in their action, but also because, in the course of time, they are subject to great change. The most accurate hygrometers are those constructed on the principle of condensation or of evaporation. Daniell's and Regnault's are constructed on the principle (*Page* 89) of ascertaining the dew-point temperature. Daniell's is the simplest, but Regnault's requires less time in making the observations. The dry and wet bulb thermometer is the most convenient. Some precaution is required in taking the observations when the temperature of the air is below 32°. If the wet bulb reads higher than the dry the observation should not be recorded. If the muslin is (*Page* 90) dry it should be wetted, and time allowed for the water to freeze before reading the temperature. When the temperature rises above 32° the ice should be removed. Both the thermometers should be exactly the same. All foreign matter should be washed out of the cotton or muslin. The water

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used should be pure, either rain or distilled. The muslin should not be touched with the fingers, which cause it to become slightly greasy. The glass vessel should be as far as possible from the dry bulb. The best hours for observation are 9 A.M. and 9 P.M. An additional observation is recommended at 3 P.M. By means of observations of the dry and wet bulb thermometers we may determine or approximate to by means of tables: (1) The dew-point; (2) the elastic force of vapour; (3) the quantity of vapour in a cubic foot of air; (4) the additional vapour required to saturate a cubic foot of air; (5) the relative humidity; and (6) the weight of a cubic foot of air at the pressure prevailing when the observation is made. (*Page* 92). The elastic force of vapour may be regarded as representing the absolute quantity of vapour suspended in the atmosphere. It may also be termed the absolute humidity. It is greatest within the tropics. It is greater at midday than in the morning. It also diminishes with height, but the average rate at which it diminishes is not known. The balloon ascents of Mr. Glaisher and some other aeronauts have thrown some light on the question. But the number of ascents are by far too few to warrant the drawing of general conclusions as to the mean rate of the decrease. The chief point established is that in particular instances the decrease is generally far from uniform, as different strata are super-imposed on each other, differing widely as regards dryness and dampness. Relative humidity is distinct from this, and by humidity of air meteorologists mean the degree of its approach to saturation. Air of a humidity of 73° would feel very dry to an inhabitant of Great Britain, 73° being about the lowest mean humidity that occurs in Scotland during May, the driest month. This low humidity is, however, greatly exceeded when the east winds of spring happen to acquire their greatest virulence and dryness. Thus during May 1866, at Corrimony in Inverness-shire, the dry bulb at 9 A.M. of the 21st was 65°, and the wet 47°, thus giving a humidity of 29°, perhaps as low a humidity as has hitherto been observed in the British Isles; and of course later in the day this extraordinary dryness must have been still further increased. In the ocean at a distance from land the humidity is always great, and during the (*Page* 94) night generally approaches 100°. In the interior of continents it is less, especially in sandy deserts, which allow the rain water speedily to sink, thus drying the surface; and in rocky countries which are never wetted more than on the surface. Thus at Djeddah, in Arabia, on 12th March, 1864, the humidity was as low as 11°. The humidity is greatest during the night, when the temperature is at its minimum; it is also great in the morning, when the sun's rays have evaporated the dew and the vapour has not yet had time to find its way into the air. And it is least during the greatest heat of the day, and for some time thereafter or before the temperature has yet begun perceptibly to fall. Now between the vapour present in the air and the temperature of the air there is a vital and all-important connection (*Page* 99) which recent experiments and researches have done much to elucidate. When rivers are considerably warmer than the air they give rise to fogs, because the more rapid evaporation from the warm water pours more vapour into the atmosphere than it can hold suspended in an invisible state, and the surplus vapour is condensed into mist by the colder air through which it rises. Thus deep lakes and rivers flowing out of them are in winter generally much warmer than the air, and hence, when the air is cold and its humidity great, they are covered with fogs. When Sir Humphry Davy descended the Danube in 1818, he observed that mist was always formed during the night, when the temperature of the air on shore was from 3° to 6° lower than that of the stream; but when the sun rose, and the temperature was brought to an equality, the mist rapidly disappeared. The densest fogs occur during the cold months in large towns built on rivers, the causes which produce fogs being then at the maximum. The denseness of the London fogs is notorious. This peculiar denseness is caused by the warmth of the river bed, and

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it is increased by the sources of artificial heat which London affords; and from the circumstance that the temperature is falling everywhere, and the humidity being then great, the vapour of the atmosphere is quickly and copiously condensed by the gently flowing cold easterly winds which generally prevail in November. In all these cases fogs are very locally distributed, being confined to the basin of the river or lake where they are formed, and do not extend far up into the atmosphere. There are, however, other fogs that spread over large districts which are originated under different meteorological conditions. Fogs often accompany the breaking of frosts in winter. For when the humid south-west wind has gained the ascendency, and is now advancing over the earth's surface as a light air, it is chilled by contact with the cold ground, and its abundant vapour thereby condensed into a wide-spread mist. Hills and mountains are frequently covered with mists. Since the temperature of the air falls with the height, it follows that as the warm air is driven up the slopes of the mountains by the wind, it becomes gradually colder, and its capacity for moisture is thereby diminished until condensation takes place, and the (*Page* 100) mountain is swathed with mist. Owing to the peculiarity of their temperature, forests have a marked effect on the mists of mountainous regions. Mists often appear sooner on the parts of hills covered with trees than elsewhere. This happens especially when the mist begins to form after midday, because then the temperature of the trees is lower than that of grassy slopes. Mists also linger longer over forests, probably on account of their increased cold arising from the large extent of evaporating surface presented by their leaves when drenched with mists. During his residence at the Cape of Good Hope, Sir John Herschel observed a remarkable instance of the influence of trees in condensing the vapour of the atmosphere. On the side of Table Mountain from which the wind blew, the clouds descended very low, frequently without any rain falling, while on the opposite side they covered the mountain in dense masses of vapour. When walking beneath tall fir-trees, at the time these clouds were closely overhead, he was subjected to a heavy shower of rain; but on going out from beneath the trees the rain ceased. The explanation he gave of the phenomenon was that the clouds were condensed into rain on the cool tops of the trees. And doubtless the innumerable fine leaves of the fir-trees adding largely to the surface of evaporation, increased the cold, which condensed the vapour into a more copious shower. I am informed by the Rev. J. Farquharson, Selkirk, that when the atmosphere is very moist, and the S.W. wind is blowing strongly, a mist or cloud is sometimes seen to settle over Bowhill, which is situated at the junction of the Yarrow and Ettrick; and that the cloud thus formed is subject to great and rapid changes, both as regards its outline and its size. This is a highly instructive observation considered with reference to the causes which produce the phenomenon. Both valleys lie nearly in the direction of the S.W. wind, but the vale of Ettrick is the more highly wooded of the two; hence the temperature of the two valleys will, from what has been stated above, be generally different the one from the other. Now when a steady humid S.W. wind is blowing, each will acquire the temperature of the valley down which it has flowed, and be at the same time near the point of saturation; and at Bowhill, where the two aerial currents meet and mix together, cloud will be formed, in accordance with the well-known law by which two volumes of air, each saturated but of different temperatures, can, when mixed, no longer hold all the vapour in suspension, so that consequently part is condensed into cloud or vapour. Extensive fogs also prevail (*Page* 101) where great differences occur in the temperature of contiguous regions. Thus promontories running out into the sea are frequently enveloped in mist; for since land is generally warmer than the sea in summer and colder in winter, the difference of temperature is generally sufficient to cause mists with the veerings of the wind landward or seaward. The same cause explains the mists and fogs which

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frequently prevail on the coast. These mists generally occur in the morning and evening, seldom advance far inland, and usually accompany fine weather. The British Isles being bounded by the warm waters of the Atlantic on the one side, and separated from the Continent on the other only by narrow belts of sea, are subject to fogs during winter. For the same reason dense thick fogs are prevalent in Norway, Newfoundland, along the coast of Peru and South Africa, and in the Polar regions. The Gulf Stream is notorious for dense and long-continued fogs, particularly at its northern limit, where it meets the Polar current. The high temperature of the stream, which is often from 16° to 18° and sometimes 30° higher than that part of the sea past which it flows, fully explains the denseness and persistency of these fogs. Occasionally the summit of a hill or isolated peak is wrapped in mist or cloud, while elsewhere the atmosphere is clear, and though a breeze be blowing over the hill, still

'Overhead
The light cloud smoulders on the summer crag,'

apparently motionless and unchanged. This phenomenon is instructive and easily explained. The temperature at the top is below the dew-point of the atmospheric (*Page* 102) current. Hence when the air rises to this region its moisture is condensed into cloud, which is borne forward over the top of the hill and down the other side, acquiring heat as it descends till it is again dissolved and disappears. Meanwhile its place is constantly supplied by fresh condensations which take place as the current, rising to the height of the cloud, falls below the temperature of saturation. Thus, though the cloud on the top of the hill appears to remain motionless and unchanged, the watery particles of which it is composed are continually undergoing renewal. There is another sort of fog of occasional occurrence differing from any of the foregoing, which, from its relation to storms, is of considerable importance in meteorology. It would appear to arise from the juxtaposition of the Polar and equatorial currents. When these currents flow side by side, fog frequently fills up the comparatively calm space intervening between them. It results from the mixing together of the two currents, the cold of the Polar current condensing the vapour of the S.W. wind. It sometimes stretches several hundred miles in the form of a long narrow strip. At other times, and more usually, it is a precursor of storms, which succeed fine dry weather, during which the wind has been chiefly from the N.E. The S.W. wind is seen to prevail in the upper regions of the atmosphere, by the direction in which the thin cirrus cloud is blown, some time before it is felt on the surface of the earth. During this interval the humid equatorial current overlaps the Polar current, and the fog which prevails is due to the mixing of the two currents. Hence in discussing storms, fogs constitute one of the most important elements which require consideration, and they supply valuable help towards the foretelling of storms. Clouds, mists, and fogs arise from the same causes. During the warmest part of the day, when evaporation is greatest, moist air currents are constantly ascending from the earth. As they rise in succession, the moist air is pushed high up into the atmosphere, and losing heat by expansion, a point is at length reached when it can no longer retain in solution the moisture with which it is charged; hence condensation takes place, and a cloud is formed, which increases in bulk as long as the air continues to ascend. But as the day (*Page* 103) declines, and evaporation is checked, the ascending current ceases, and the temperature falling from the earth's surface upwards, the lower stratum of the air contracts, and consequently the whole mass of air begins to descend, and the clouds are then dissolved by the warmth they acquire in falling to lower levels. The whole of the process is frequently seen on a warm summer's day. In the morning the sky is cloudless, or nearly so; as the heat becomes greater, clouds

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begin to form, and increase in number and size, often presenting scenes of unparalleled beauty, as lighted up by the sun into dazzling brilliance, they sail slowly and smoothly across the blue sky; but as the heat diminishes, they contract their dimensions and gather round the setting sun, lit up with the fiery splendours of his beams. In a short time they disappear, and the stars come out, shining in a cloudless sky. When a dry and heavy wind begins to set in, or takes the place of a moist and light wind, it generally does so by edging itself below the moist wind, and forcing it wedgeways into the upper regions of the atmosphere, where condensation rapidly follows, and dense black clouds, often heavily charged with rain, are formed. This is a frequent cause of cloud and rain in Great Britain, when the cold heavy east wind or Polar current thrusts high up into the air the rain-bringing S.W. wind, thus causing it to darken the sky and bring down its surplus moisture (*Page* 104) in torrents of rain. Espy has reasoned that every cloud is either a forming cloud or a dissolving cloud. While it is connected with air-ascending currents it increases in size, is dense at the top, and well defined in its outlines; but when the ascending current ceases, the cloud diminishes in size and density. When a cloud overspreads the sky its lower surface is, for the most part, horizontal, or more generally, it seems as if it was an impression taken from the contour of the earth's surface beneath it. This arises from the high temperature of the air below the cloud, which is sufficient to dissolve the particles as they descend below its level. On ascending through this lower stratum of cloud the temperature is found frequently to rise, and the air to be quite clear of clouds for a considerable thickness. Higher up a second stratum of cloud succeeds, and again another clear space, and so on, cloud and clear sky following each other several times in succession. These phenomena arise from the different currents which are encountered superimposed over each other, and differing in temperature and humidity. Kaemtz has deduced (*Page* 105) the heights between which clouds range as from 1,300 to 21,320 feet. The extreme height is, however, much too small, as has been proved by balloon ascents. Thus Gay Lussac in September 1804, when at the height of 23,000 feet, saw clouds floating apparently at a great height above him. It is probable that the cirrus cloud is often ten miles above the earth. Since clouds are subject to certain distinct modifications from the same causes which produce the other atmospheric phenomena, the face of the sky may be regarded as indicating the operation of these causes. The ancient meteorologist was content with discerning the face of the sky, in order to predict the coming weather. It is to this that the weather-wise sailor and the farmer still look in foretelling the weather. The classification of clouds universally adopted is that proposed by Luke Howard in 1803. The cirrus is the cloud first seen after serene weather. The duration of the cirrus varies from a few (*Page* 106) minutes to many hours. It remains for a short time when formed in the lower parts of the atmosphere, and longest when it appears alone in the sky, and at a great height. The cirrus, though apparently motionless, is closely connected with the movements of great atmospheric currents. It is this intimate connection which has long caused it to be considered as a most valuable prognostic of stormy weather, and as such it deserves more attention than has hitherto been given to it. Small groups of regularly-formed and arranged cirrus scattered over the sky often accompany fair weather and light breezes; these do not indicate the approach of a storm for some time at least. Horizontal sheets of this cloud, which fall quickly, and pass into the cirro-stratus cloud, indicate in an unmistakable manner continued wet weather, when streaks of cirrus run quite across the sky in the direction in which a light wind happens to blow, the wind will probably soon blow hard, but it will continue in the same direction; in other words, the variable winds and fitful gusts which accompany storms are not likely to be experienced when the fine threads of the cirrus appear blown, or brushed backwards at one end, as if by a

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wind prevailing in those upper regions, the wind on the surface will ultimately veer round to that point. If the direction indicated be from south-west, whence the storms of Europe come, wind and rain may be expected; and it matters not how fair and settled like the weather appear at the time, a storm more or less severe is advancing, and may be looked for within thirty or forty-eight hours. When the storm seems past, and the sky has cleared, should a few fine cirrus clouds be seen slightly blown back at their eastern extremities, the storm has in all likelihood really passed, and fair weather may be expected with some confidence, since the dry Polar current has already begun to prevail overhead. But if, instead of this, innumerable groups and streaks of cirrus cover the sky, crossing each other in all directions, and presenting the appearance of a skein of yarn inextricably tangled together, we may be sure a second storm will shortly follow the one already past. The cumulus clouds are formed in the lower regions of the atmosphere, and are carried along in the current next the earth. The cumulus has been well called the cloud of day, being caused by (*Page* 107) the ascending currents of warm air which rise from the heated ground. When the cumulus clouds are of moderate height and size, of a well-defined curved outline, and appear only during the heat of the day, they indicate a continuance of fair weather. But when they increase with great rapidity, sink down into the lower parts of the atmosphere, and do not disappear towards evening, rain may be expected. If loose, fleecy patches of cloud begin to appear, thrown out from their surfaces, the rain is near at hand. The stratus is the lowest sort of cloud, its lower surface commonly resting on the earth. The stratus may be called the cloud of night, since it generally forms about sunset, grows denser during the night, and disappears about sunrise. It is caused by the vapours which rise during the day, but towards evening fall to the earth with the falling temperature; and since during night the cooling of the air begins on the ground, and thence proceeds upwards, the stratus first appears like a thin mist floating near the surface of the earth; it thence increases from below upwards as successive layers of the air are reduced below the point of saturation. It includes all those mists which in the calm evening of a warm summer day form in the bottom of valleys and over low-lying grounds, and then spread upwards over the surrounding country like an inundation. When the sun has risen, and begun to shine on the upper surface of the stratus cloud, it begins to be agitated, and heaved up in different places into the rounded forms of the cumulus, while at the same time the whole of the lower surface begins to rise from the ground. As the heat increases, it continues to ascend, and becomes broken up into detached masses, and soon disappears altogether. These appearances indicate a continuance of the finest and serenest (*Page* 108) weather. 'While the cirrus changes into the cirro-cumulus, it generally descends to a lower position in the atmosphere. This beautiful cloud, commonly known as a 'mackerel' sky, occurs frequently in summer, and is attendant on dry and warm weather. It is also sometimes seen between showers. But in this case the cirro-cumulus will be found wanting in the settled order which it wears in fine weather. The cirro-stratus is markedly a precursor of storms; and from its greater or less abundance and permanence, it gives some indication of the time when the storm may be expected. It may generally be seen between storms, occasionally with the cirro-cumulus, and from what then takes place, important information may be learned regarding the continuance or non-continuance of the stormy weather then prevailing. For if the cirro-cumulus give way, or pass into the cirro-stratus, more wind and rain may be confidently expected; but if the cirro-cumulus prevail, (*Page* 109) the storm is past, and fair weather may be looked for. The cumulo-stratus appears indistinctly in the intervals of showers. The distinct cumulo-stratus is formed when the cumulus becomes surrounded with small fleecy clouds just before rain begins to fall, and also on the approach of thunderstorms. The

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rain-cloud often has its origin in the cumulo-stratus, which increases till it overspreads the sky and becomes black, or bluish-black, in colour; but this colour soon changing to grey, the nimbus is formed, and rain soon begins to fall. At a considerable height a sheet of cirro-stratus cloud is spread out, under which cumulus clouds drift from the windward; these rapidly increasing, unite at all points, forming one continuous grey mass, from which the rain falls. It is evident from this that the whole mass of air under the upper sheet of cloud into which the clouds drift must be completely saturated. The breaking up of the loose grey mass indicates that the rain will soon cease. When a rain-cloud is seen approaching at a distance, cirri appear to shoot out from its top in all directions, and it has been observed that the more copious the rainfall, the greater is the number of the cirri thrown out from the top cloud. In observing clouds, the kind, the direction in which they are carried, and the proportion of the sky covered with them, should be noted. In estimating the amount, that portion of the sky from the horizon half-way to the zenith should not be taken into account, because the clouds being there foreshortened, the estimate would be too great. The scale generally adopted in this country is 0 to 10; 0 indicating a clear sky, 5 that it is half covered, and 10, (*Page* 111) that it is totally obscured. The rainfall is diminished, if the winds have passed over large tracts of land, particularly mountain ranges, and are, therefore, (*Page* 112) dry. The more specific conditions under which rain is precipitated, as stated by E. Renou, include:—1. Two layers of clouds at least—an upper layer, the cirrus, and a lower layer, the cumulus, or cumulo-stratus, which has its density increased, and its temperature lowered by the descent of the ice crystals of the cirrus. The geographical distribution of rain is proportioned to the humidity, etc. (*Page* 114) Rain rarely or never falls on the coast of Peru, in the great valley of the rivers Columbia and Colorado, the Sahara, and the desert of Gobi. The (*Page* 115) trade winds are in the condition of taking up moisture rather than parting with it; and the return trades which blow above them, having discharged the greater part of their moisture in the region of calms, are also dry and cloudless. In the region of calms the sun almost invariably rises in a clear sky; but about midday clouds gather, and in a short time the whole face of the sky is densely (*Page* 116) covered with black clouds, which pour down prodigious quantities of rain. Towards evening the clouds disappear, the sun sets in a clear sky, and the nights are serene and fine. The reason of this daily succession of phenomena in the belt of calms is that the air, being greatly heated by the vertical rays of the sun, ascends, drawing with it the whole mass of vapour the trade winds have brought with them, and which has been largely added to by the rapid evaporation from the belt of calms; this vapour is condensed as soon as it rises to the line of junction of the lower and upper trades. As evening sets in, the surface of the earth and the superincumbent air being cooled, the ascending currents cease, and the cooled air descends; the clouds are thus dissolved, and the sky continues clear till the returning heat of the following day brings round a recurrence of the same phenomena. The daily rains of the belt of calms are to some extent analogous in their origin and causes to the formation of the cumulus cloud of temperate climates. (*Page* 135) An important characteristic of winds is their quality, being dry or humid, etc., according to their direction and the nature of the earth's surface over which they have passed. Thus in the north hemisphere southerly winds are warm and moist, while northerly winds are cold and dry; and in the south hemisphere (*Page* 136) *vice versâ*. In certain parts of the earth circumstances occur intensifying (*Page* 146) these effects, and causing excessive drought, etc. In front of a storm the dew-point is high; in the rear, low; the high dew-point is accompanied by great humidity, and the low dew-point by a small one. When the barometer has been falling for some time, clouds begin to overspread the sky, and rain to fall at

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(*Page* 147) intervals; after the centre of the storm has passed, the rain becomes less heavy; the clouds break up, and fine weather ultimately prevails. The physical (*Page* 158) cause of the ascending currents in the centre of storms is to be found in the moist and warm, and therefore light, air which all observation shows to prevail in the front and in the central part of storms. And since most of the rain which accompanies storms falls in those parts of the storm, the barometer will be still further reduced by the removal of the elastic aqueous vapour which is condensed into raindrops, and by the latent heat set free in the condensation of the vapour. Storms generally contract in area as they traverse a dry climate, and die out when they come to a dry polar current, as less vapour is condensed there. The usual place where the vapour brought by the trade winds is condensed is the region of calms, where heavy rains and thunderstorms occur. But since the condensation takes place simultaneously over a somewhat broad belt of the earth's surface, which for the time is stationary, it follows that the storm is neither rotatory nor progressive, the only effect of the condensation being the flow of the regular trade winds towards the belt where it takes place. When the condensation is more copious than usual, the effect will be the acceleration of the speed of the trade winds. Suppose that the atmosphere of the West Indian islands has from some cause become exceptionally warm and moist, and that at the same time a high barometer is interposed between that region and the belt of calms. In such circumstances, as the trade winds cannot flow towards the belt of calms, the usual provision for draining them of their moisture is taken away, and a rapid accumulation of aqueous vapour takes place to the north of the high barometer, ready (*Page* 167) to burst into rain and tempest. This would appear to have been the (*Page* 180) case before and after the Bahama hurricane of October 1866. The cirrus cloud sometimes appears of a texture so delicate as to elude the eyes of all but the (*Page* 181) most practised observers, and no doubt it is sometimes so thin, that the eye cannot detect it till it is revealed by electric discharges passing through it. This cloud probably originates in the equatorial current beginning to prevail in the higher regions of the atmosphere, and depositing the watery vapour necessary for the electric discharges, the faint light of which reflected by the minute crystals of the cirrus clouds forms the aurora. A large quantity of ozone in the air is associated with increasing humidity, and a small quantity with decreasing humidity. (*Page* 182) Since rainbows in the morning are always seen in the west, they indicate the advance of the raincloud from the west at the time when it is clear and bright in the east; and since the fall of rain at this time of the day, when the temperature should be rising, is an additional evidence of increasing moisture, a morning rainbow is regarded as a prognostic of a change to wet, stormy weather. On the (*Page* 183) contrary, the conditions under which a rainbow can appear in the evening are the passing of the raincloud to the east, and a clearing up in the west at the time of day when the temperature has begun to fall, thus further indicating a change from wet to dry weather. Coronas can only be seen when the globules composing the cloud are all, or nearly all, of equal size, and the smaller the size of the globules the greater is the diameter of the corona. Hence the corona is a valuable prognostic; for when its diameter contracts round the moon, we know that the watery particles composing it are uniting into larger ones, which by-and-by will fall in rain; whereas, if the corona be extending, the particles are growing less, thus indicating increasing dryness, and consequently fair weather. Scoresby observed that Anthelia or glories are always seen in the Polar regions whenever (*Page* 185) sunshine and fog occur at the same time. The red and golden-coloured clouds are observed to be the accompaniment of cumulus clouds while in the act of dissolving, as they sink slowly down into the lower and warmer parts of the atmosphere; consequently they disappear from the sky soon after sunset. Such

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sunsets are universally regarded as prognostics of fine weather. Frequently small thin clouds appear high up in the eastern sky some time before sunrise, or when

'The dappled dawn doth rise,'

and when the sun has risen they disappear. They are probably caused by the sun shining on and warming the upper layers of the atmosphere before it appears above the horizon; thus small ascending currents are formed, the vapour of which as they ascend is condensed into small clouds, as the cirro-cumulus. Their rounded definite forms show them to be produced in the same way as the cumulus—viz., by ascending currents forcing their way through colder strata. They may thus be regarded as heralding the cumulus, and as sure prognostics of fine weather. If in (*Page* 186) the evening sky after stormy weather the yellow tint deepens into orange and red, the atmosphere is getting drier, and fine weather may be looked for. In the morning a red and lowering sky is a prognostic of unsettled weather.

(*Page* 196.) Table V. showing elastic force of aqueous vapour.

(*Page* 197.) Table VI. Factors for multiplying the excess of the dry bulb thermometer over that of the wet bulb to find the excess of the temperature of the air above that of the dew-point.

Buchan, A. *Journ. Scot. Meteorol. Soc.*, vol. ii. (1869), No. xiv., April 1867 (*rvp*).

(*Page* 41.) The irregular periods of temperature observable in Scotland are intimately connected with the direction of wind, and with the absolute and relative quantity of the vapour in the air. The effect of a diminished quantity of vapour in raising or depressing the mean temperature depends on the season of the year. If it occurs in summer, the mean temperature will be raised; but if in winter, it will fall. As concerns evaporation, great humidity adds to the mean temperature, and a small humidity lowers it. But as compared with solar or terrestrial radiation the effects of evaporation on the temperature are very slight. The following examples illustrate the dependence of the changes of temperature on the amount of vapour in the atmosphere. Lieut.-Col. Strachey (*Phil. Mag.*, 1866) has examined the Madras meteorological observations of several years, and compared the elastic force of the vapour with the number of degrees the temperature was reduced by terrestrial radiation from 6.40 P.M. to 5.40 A.M., and the number of degrees the solar radiation was raised from 5.40 A.M. to 1.40 P.M. In all cases examined, the sky was either quite, or all but quite, free from clouds; the only difference being in the amount of vapour. The following are selected from the results arrived at:—

TERRESTRIAL RADIATION.

Tension of vapour	·888 in.	·605 in.	·455 in.
Fall of temperature from 6·40 P.M. to 5.40 A.M.	6°	12·1°	16·5°

SOLAR RADIATION.

Tension of vapour	·824 in.	·670 in.	·394 in.
Rise of temperature from 5.40 A.M. to 1.40 P.M.	12·4°	19·3°	27·0°

Thus when the quantity of vapour in the air was very large (tension ·888 in.), the temperature only fell on an average 6° during the night; but when the quantity of vapour was small (·455) the temperature fell 16·5°. And when the quantity of vapour was large (·824) the temperature during the day rose only 12·4°; but when the amount of vapour was small, the temperature rose in the same space of time 27°. These remarks will be applied to the August cold and warm periods. The mean tension of vapour at Sandwick for August is ·360 in. For the four cold days it is only ·353 in., and on the 9th as low as ·343 in.; but for the four warm days immediately following it is ·396 in., or ·043 in. greater. The mean humidity of the

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month is 85 ; of the four cold days 84 ; of the four warm days 89. Thus then, from the 8th to the 11th of August, characterised by a depression in the temperature, there was a diminished amount of vapour and less humidity. But from the 12th to (*Page* 43) the 15th, when the temperature rose, the tension increased about ·05 in. and the humidity increased from say 84 to 87. These two periods present a very striking character as regards the moisture of the air,—the warm period from the 12th to the 16th showing an amount of vapour in the atmosphere such as occurs at no other time of the year, and the cold weather of the four days preceding a deficiency of vapour greater than occurs during August until the close of the month, when, owing to the falling of temperature, the quantity of vapour is diminished. If the cold period of August was caused by the interception of heat by meteors, we should then expect with the fall of temperature an increase in the rainfall, and as the temperature would thus be brought nearer the dew-point, an increase in the humidity ; and after the earth has emerged from the shadow of the meteors along with the rise of temperature, we should have a diminished rainfall and less humidity. Since the reverse of this happens, the cold of August must be explained by other causes. For this no combination of circumstances can be considered adequate which does not account for the dry, cold air prevailing during the cold period, and the warm, moist air during the warm period.

[He then investigates the condition of Western Europe as regards wind, atmosphere, pressure, and temperature relatively to Scotland, and arrives at the conclusion that the cold and warm periods of August are determined by the wind, and that the observed relations of moisture depend on the wind. The whole inquiry has a local bearing, and therefore the details are omitted here.]

Calvert, H. H. *Journ. Scot. Meteorol. Soc.*, vol. ii. (1869), No. xvi., October 1867 (*rvp*).

(*Page* 115.) At Erzeroom, June is remarkable for the regularity of the daily atmospherical change. At sunrise the sky is perfectly bright ; towards 10 A.M. clouds begin to appear, which gather rapidly ; and at noon, or 1 P.M., the heavens are quite overcast with heavy thunder clouds. At about 2 P.M. thunder is heard. Towards sunset the clouds are gradually dispelled, and by 9 or 10 A.M. the sky reassumes its clearness.

Laughton, J. K. (*B.* 1867, 12.)

(*Page* 445.) The dew-point in the equatorial oceanic district is perhaps seldom so much as 5° below the air temperature. Daniell has estimated the difference as generally 2° or 3°.

Lyell, Sir Charles. (*B.* 1867, 13.)

(*Page* 271.) Croll observes that when the winter occurs in aphelion during a high eccentricity of the earth's orbit the aqueous vapour would fall as snow in high latitudes, and during the summer, when the heat would be one-fifth more intense than at present, the melting of the accumulated ice and snow would give rise to (*Page* 286) constant fogs and overcast skies. When certain dry winds blow the snow wastes away like camphor by evaporation ; and as it is observed that the rainfall diminishes towards the poles, it is probable that the snowfall also diminishes in that direction, so that there may be a dry air at the poles, especially if warm air from (*Page* 430) the south parts with its moisture in passing over snow-clad areas. The evaporation from some lakes is nearly equal to the quantity flowing in ; and in the (*Page* 497) Caspian quite. [He says solar evaporation is a cause of oceanic currents. If so, then such currents may in some cases afford valuable evidence as to the distribution of aqueous vapour.]

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Markham, C. R. *Journ. Roy. Geog. Soc.*, vol. xxxvi. (1867) (*rs*).

(*Page* 89.) The effect of vegetation is undoubtedly to retard evaporation and to check the rapidity of drainage; and the removal of forests of course has an opposite effect. The hill districts of India afford proofs of this. The floods caused by the monsoon rains are yearly increasing in size and violence.

Mitchell, A. *Journ. Scot. Meteorol. Soc.*, vol. ii. (1869), No. xv., July 1867 (*rrp*).

(*Page* 80.) The injurious effects of the March winds of Scotland are due to their coldness and dryness. Such winds blowing over a moist surface tend to reduce the temperature of that surface to the temperature of evaporation, and thus ab-
(*Page* 81) stract a large quantity of heat. Places protected from the wind will have less evaporation. The proverb says: 'Better be bitten by a snake than
(*Page* 82) warmed by a March sun.' The risk may be owing to the diathermancy of the air, which is due to its dryness. It may be said that the moisture of the air is the preserver of life; for without it every living thing would be burnt to death after sunrise or frozen to death after sunset.

Moore, J. W. *Symons's Meteorol. Mag.*, vol. ii. (1867) (*rsp*).

(*Page* 118.) The explanation of the peculiar haze which accompanies an easterly wind lies in its dryness, coldness, and consequent density with but a small capacity for vapour. The effect of its dryness—the result of its passage across land and of its coming from intensely cold regions—is excessive evaporation. But the vapour drawn up in this way is immediately condensed before it can reach to any height by the extreme coldness of the air, not in the form of a cloud, but as a haze of a most peculiar bronze hue. And this is more marked in spring, because at that season (*Page* 119) the coldness of the N.E. current is greatest and the amount of vapour carried up by evaporation reaches a maximum, from the sun, with increasing power, acting on the land drenched by the winter's snow and rain. With respect to the S.E. wind; in the first place we must carefully distinguish two distinct forms of the same. The one is nothing more than a bent polar or N.E. current, and is accompanied by all its characteristics—viz., a high barometer, great cold, the usual bronze hue, dry weather, etc. The other is a deflected S.W. or equatorial current, and is attended with a low barometer, warmth, moisture, and often heavy rain. The latter occurs in two aspects; first, as forming one side of a cyclone, which is the most usual; and secondly, as a comparatively steady wind, the result of an equilibrium established by opposite currents from N.E. and S.W. holding each other in check. If in the second case there is no intermingling of currents, we have towards the S.W. border of the S.E. wind a singularly transparent air and large quantities of cirrus, and towards the N.E. edge of the same the haze and high barometer characteristic of N.E. wind. The colour of the E. wind haze is the same as that of the inner edge of a solar halo, and is no doubt due to a peculiar arrangement of the vapour particles.

Russell, R. *Symons's Meteorol. Mag.*, vol. ii. (*rsp.*)

(*Page* 117.) Tyndall has exaggerated the influence which the vapour of water exerts in modifying the intensity of solar and terrestrial radiation. The radiant power of the atmospheric vapour would not form clouds, though it might form mists. In our atmosphere [English] the vapour of water had little power of transmitting its heat into space when it approaches or reaches the dew-point. If any cloud had been caused by the radiation of heat into space its upper surface would be flat, like the mists in the meadows before sunrise. These and other reasons led him to the

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conclusion that the radiation of heat into space has directly a very slight influence on the production of rain.

[Sir W. Thomson's remarks on this paper will be found under his name at the bottom of this page.]

Sorby, H. C. (*B.* 1867, 16.)

(*Page* 357.) The blue colour of the sky is due to the absorption of a considerable amount of the red light by the vapour of water present as a transparent gas in a clear pure atmosphere. If, however, minute particles of water are present in the form of thin mist, the depth of the blue colour will be diminished, and hence in winter and in cold countries we have not the clear, deep blue sky of summer or of subtropical districts. The blue colour of mountains may also be explained in the same way, being due partly to the influence of the aqueous vapour, and partly to the shaded parts being illuminated by the blue sky. If the air be much charged with dry transparent vapour, the blue colour will be deeper, whereas if there be any fog or mist it will be obscured, and hence the blue colour is a sign of the air being loaded with vapour.

Stow, F. W. *Symons's Meteorol. Mag.*, vol. ii. (*rsp.*)

(*Page* 82.) At Tunbridge Wells on 27th June, four feet above ground, the humidity sank to 29·6 at 2.30 P.M. The least vapour occurred at noon; dew-point 41·1°. The temperature of the dew-point was so uniform throughout the day, that from the temperature of the air the reading of the wet bulb, almost at any time, might have been predicted when the dew-point had once been ascertained. This seems to be generally the case, at least in dry weather.

Symons, G. J. *Symons's Meteorol. Mag.*, vol. ii. (*rsp.*)

(*Page* 68.) The driest day I have hitherto recorded at Camden Town was on June 28th, 1857, when the humidity was as low as 33. On June 27th, 1867, it reached 29 at 3 P.M. four feet above the ground, the wet bulb being 58·1° and the dry 78·5°. At twenty feet above ground the lowest was at 2 P.M., being 36; dry bulb 77·1°, wet (*Page* 69) 59·9°. The dryness was much greater near the earth than at twenty feet above it. In both years the greatest drought was preceded by a period of easterly winds and high barometer. The range of temperature was also greatest in 1867. It was 35·1° in 1867; 31·3° in 1857. At Aldershot Mr. Arnold registered a humidity of 22 at 3 P.M.; dry bulb being 82°, wet 57°.

Thomson, Sir W. *Symons's Meteorol. Mag.*, vol. ii. (*rsp.*)

[Remarks made in a discussion on Russell's paper referred to under his name.]

(*Page* 117.) He thought Russell was right that the cold of expansion had a very small effect in causing torrents of rain; but that he had undervalued very considerably the influence of radiation in producing that minor condensation by which mists and clouds were constituted. He said minor condensation, meaning condensation from a gaseous condition into small spherical globules, was so small that the resistance they met with kept them suspended. The reason why a cloud did not fall down as rain was that every part of the cloud was composed of very minute drops of water. The larger the drops were that constituted a cloud the more rapidly would they fall; but when very small they fell insensibly, as Professor Stokes has shown, only perhaps a few inches in an hour. When somewhat larger, they formed what we called a Scotch mist, which was something between a shower of globules coming down appreciably, and a shower of globules in which the descent was insensible. As to the influence of radiation and the influence of minor condensation as

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soon as a cloud exists, whether high or low, each particle becomes a radiator. It radiates heat and becomes itself a little cooler than the surrounding air, and so becomes a reservoir of condensation. That takes place at the top of the cloud if there is clear air above it, and so with the mists of the valleys. A blade of grass (*Page* 118) could not go to a temperature lower than the dew-point of the air touching it, and so was it with particles of mist. By an arrangement which they could not but regard as an admirable and wonderful exemplification of design, there was nothing destitute of protection. The protection was sometimes insufficient, and plants were killed by frost: but some degree of protection was never wanting, and there was enough of that protection always to allow plants to live, as we saw them doing, and to survive during weather when, were it not for one of these causes, the cold would be so great as to destroy them altogether. Physically it was interesting to remark how it was that in each instance the protection was obtained. There was first the protection afforded by clouds. These prevented the surface of the earth from radiating and reaching a lower temperature than that of the clouds. The temperature of a blade of grass on a cloudy evening would therefore be very nearly the temperature of the lower surface of the clouds overhead. When there were no clouds and no wind the office of each blade of grass was to collect the air touching it, condense vapour from that air, and to take heat from part of the air around it. Thus we had a source of heat taken from the air several feet above the surface. The protection was more complete, however, when dew did not fall, for when there was no dew, the wind made up so large a portion of heat from the air that the leaves of plants were never allowed to go down even to the dew-point. Thus wind was a more complete protection than dew, and it would have been observed that plants were never injured by frosts on windy nights, and that in the morning the grass was found dry. It was sometimes remarked that flowers were frosted in hollows, but that close at hand and on hillocks they escaped damage. The air in the hollows remained unchanged, and unless there was moisture enough in the air to provide dew as long as the severe conditions of weather lasted, and to keep the dew point from going down too low, injurious effects would follow. The plants, in short got dry, drying the air around them, and if that air was not changed very much for the better then they were destroyed by frost. This, however rarely happened.

Georg Ludwig von —. *Journ. Roy. Geog. Soc.*, vol. xxxvi. (1867) (*rs*).

(*Page* 273.) Akhtulimba (in the Belor country). Fog is of frequent occurrence in spring, and is called omimir. The mist lasts till two o'clock in the afternoon, when it suddenly disappears.

Journ. Scot. Meteorol. Soc., vol. ii. (1869), No. xvi., October 1867 (*rvp*).

(*Page* 122.) The observer at Glencairn remarks that according to the old saw the leafing of the oak before the ash indicates a dry summer. [The observer is Rev. Robert Home.]

Symons's Meteorol. Mag., vol. ii. (*rsp.*)

[No. for April 1867.]

(*Page* 35.) Steinmetz in his 'Sunshine and Showers' says: 'Much wet in May is worse than excessive drought'; hence the proverb—

'A May flood
Never did good.'

It is said that a great drought always enters during the period comprising the last eight days of February and the first twenty days of March. He also states that rain-clouds are attracted to certain localities more than others.

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Symons's Meteorol. Mag., vol. ii. (*rsp.*)

[No. for July.]

(*Page* 67.) Saussure notices that before his time the hygrometers in use were formed of strings, animal fibres, and other substances which elongate or contract with damp. He points out that no one had examined the effect on any of them of variation in the pressure, density, movement, etc., of the air, nor had they examined if the varying indications of the instrument were proportional to (*Page* 68) the amount of vapour in the air. The l'Abbé Fontana rendered the method of indicating the humidity adopted by the Academicians of Cimento more portable by weighing a clean, well-polished plate of glass, reducing it to a certain temperature, and then reweighing; the difference representing the moisture condensed on it. Le Roi stood a glass in water, cooled the water till dew stood upon the glass, and then registered the temperature. Saussure rejects all these on account of inconveniences attending their use, and the liability to disturbances in the indications from the presence of grease and from other causes. Saussure tried sal-ammoniac in Le Roi's process, but states that he found that the dew did not appear at the same temperature under apparently the same circumstances. Saussure often suspended his hygrometer four feet above the (*Page* 88) ground in the middle of a large plain, waited until it took exactly the humidity of the air, and observed afterwards its momentary variations. We know that there are days when the air is calm, or no violent or decided wind agitates it; but, nevertheless, in a place perfectly open there arise from time to time slight breezes which give a momentary agitation. He invariably remarked that (*Page* 89) these slight breezes, from whatever quarter they came, caused the hygrometer to go towards dry, sometimes 1°, sometimes 2°; after which, when the air became dry, it retreated little by little to the point at which it was previously. Reflecting that these puffs arising all at once in the middle of a calm cannot surely come from far, that they are, in fact, but portions of the surface air of the same plain, compelled by a momentary rupture of equilibrium to change places; in such a plain, when the air is calm, it may be assumed that the whole was nearly of the same humidity. Why, then, should these breezes always give drier indications? Returning home he suspended the same hygrometer in the middle of a room, closed the doors and windows, sat down six feet from the hygrometer, over which he had suspended a large screen, waited quietly until he was certain that the screen and hygrometer were in the same state as the air of the room, and had taken up all possible effect from the presence of his body; then, without changing his position, he agitated the screen rapidly (like a fan); at the end of eight or ten minutes he found the hygrometer indicated $\frac{3}{4}$° drier. From subsequent rough experiments Saussure decided that these effects were due to the mingling of air from a higher level, which he assumed to be always drier. We think the point open to further investigation, the relation of aspirated and ordinary dry and wet thermometers being, we believe, only a partially investigated question. Saussure's third essay is an excellent *resumé* on evaporation. When speaking of evaporation he ridicules the idea of evaporation from a small vessel of water in a garden representing that of a large water surface like a lake or sea, and says that in order to do this fairly we should have the vessel floating even on the surface of the sea, and with the water as near as may be at the same level. The evaporator should be of such size that the water is at the same temperatures. He adopts Richmann's suggestion that the water surface should be nearly at a constant level. He notices that ice is subject to evaporation, and proves that the rate of evaporation from it is proportional to the humidity of the air. In his fourth essay he says it is the coldness of the upper regions of the air which retains and imprisons the water which nourishes the surface of the earth. Dew, which we may regard as a species of rain without clouds is

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(*Page* 90) explained in the same manner; nevertheless it is sometimes accompanied by fog, and even this vapour which renders the air slightly thick when the dew falls is produced probably by some of the vesicles which are formed when cooled air is depositing its superfluous humidity. He criticizes Bouguer for limiting the altitude of the clouds to 8,000 feet, and says they may exist at 168 miles.

Notice of Clouston's Explanations of Weather Prognostics (same vol.).

(*Page* 93.) Easterly gales without rain during the spring equinox foretell a dry summer. Dr. Kirwan's rules, verified by Howard in 1808, are (1) when there has been no storm before or after the vernal equinox the ensuing summer is generally dry, at least four times in six; (2) when a storm happens from an easterly point on the 19th, 20th, or 21st of March, the succeeding summer is dry four times in five; (3) when a storm rises on the 25th, 26th, or 27th of March, and not before, in any point, the succeeding summer is generally dry four times in five. Dry summers, Dr. Kirwan says, are a consequence of uniform winds, from whatever quarter they may blow; as wet summers are of variable winds, particularly in opposite directions.

1868.

Buchan, A. *A Handy Book of Meteorology.* 2nd Ed. (*rv.*)

(*Page* 35.) It is probable that the vapour of water exerts a pressure on the barometer in another way than by its elastic force. The maximum barometric (*Page* 36) pressure in the forenoon is brought about by the rapid evaporation arising from the dryness of the air and the increasing temperature, together with the overflow of air in the upper regions of the atmosphere from the wave of heat which (*Page* 39) has been going on for some hours. In the neighbourhood of the equator, where the temperature and moisture differ little in the course of the year, there is little variation in the mean pressure from month to month. Thus at Cayenne the (*Page* 40) pressure in January is 29·903 in., and in July 29·957 in. The low winter pressure at Reykjavik, Sandwick, and Sitka is due to the comparatively high winter temperature, the large amount of moisture in the air, and the heavy (*Page* 47) rainfall. The July distribution of atmospheric pressure is due primarily to temperature, and secondarily to the moisture of the atmosphere. The effect of the Mediterranean, Black Sea, Caspian Sea, North Sea, and Baltic Sea, in deflecting and otherwise determining the position of the curves of pressure is very interesting. Air charged with vapour of water is considerably lighter than dry air; consequently when moist air accumulates over any region an ascending current takes place. But as moist air ascends into the upper regions of the atmosphere, it is cooled below the point of saturation, condensation follows, and rain is precipitated. In the act of condensation heat is liberated which, by heating the air in the higher parts of the atmosphere, tends still further to diminish the pressure, and so accelerates the ascent of the current. This influence of the vapour on the isobarometric curves is illustrated in Plate I. [not given here]. In the North Pacific, where at this season the two trade (*Page* 50) winds meet and mingle, there occurs a belt of low pressure caused by the vapour accumulated by these constant winds. In the Atlantic at 15° N. lat. there is a similar belt of low pressure, at least lower than what prevails to the north and south of it. The crowding together of the isobarometric lines in the south and east of Asia is caused by the vapour which the summer monsoon brings to these regions, and which is there precipitated in a copious rainfall. The low pressures which prevail during all seasons in the Antarctic Ocean are no doubt due to the saturated state of the atmosphere resulting from the N.W. winds, which blow thither from an almost unbroken sheet of waters which embraces the S. Pacific, the S. Atlantic, and the Indian Ocean, and which meet with little land to condense the (*Page* 52) vapour till they flow within the Antarctic Circle. Two of the January areas of diminished pressures are caused by there being vast reservoirs of moist air—

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viz., the north part of the Atlantic and the north part of the Pacific, and the parts (*Page* 55) of the continents adjoining. The influence of high temperature in lowering the mean annual pressure over any portion of the earth's surface is slight, as compared with the depressing influence of the vapour of the atmosphere. It may therefore be concluded that the chief disturbing influences at work in the atmosphere are the forces called into play by its aqueous vapour—thus giving to this element a paramount claim on our regard in studying winds, storms, and other (*Page* 95) atmospheric changes. The quantity of dew deposited is in proportion to (*Page* 124) the degree of cold produced and the quantity of vapour in the air. Illustrations of this [that is the effect of mountain ranges in drying winds and thereby increasing radiation to the leeward, so as to make the temperature range greater] (*Page* 129) are afforded by Norway and Sweden and the British Isles. In summer (*Page* 131) the interiors of continents are hotter and drier. When an area of low pressure is bordered on either side by an area of high pressure, long-continued rains occur in the area of low pressure, while on the southern side the weather is close (*Page* 148) and warm. Though in exceptional cases the amount of vapour indicated by hygrometers may be wide of the mark, yet, in long averages, a very close approximation will be obtained, except in confined localities, which are exception- (*Page* 153) ally damp or exceptionally dry. Professor Elliott remarks that (*Page* 154) moss can retain five times its weight of water on the surface of the soil always prepared for evaporation, and prepared in the manner that it can most readily evaporate. No one need be astonished at the coldness of our hills and the dampness of our mountain climate when they consider that the surface of the soil is either moss or grassy turf. This moss or turf retains most of the water that falls from the clouds, permitting little, except in very wet weather, to enter the soil; this water is almost immediately evaporated, and the turf prepared to receive other supplies. The coldness caused by evaporation must therefore be very great. It follows from this that the conversion of a swamp or a low-lying damp piece of ground into a lake will add materially to the dryness and amenity of the climate of the surrounding district, and the rainier the locality the greater will be the advan- (*Page* 171) tage gained. Dr. James Bryce notices that occasionally a cloud is formed at Brodrick at the point where Glens Rosa and Shiraig meet. The explanation is the (*Page* 186) same as that of the cloud formed at Bowhill. Rain sometimes falls from a cloudless sky. Sir C. Ross describes a case which occurred near Trinidad, December 25th, 1839. It was a beautiful clear night, not a cloud to be seen, yet there was a light shower of more than an hour's continuance. The temperature of (*Page* 212) the dew-point was 72, of the air 74. Differences of atmospheric pressure, and consequently all winds, arise from changes occurring either in the tempera- (*Page* 213) ture or in the humidity of the air. If the atmosphere of one region become more highly charged with aqueous vapour than the atmosphere of surrounding regions, the air of the more humid atmosphere being on that account lighter will ascend, while the heavier air of the drier regions will flow in below and take its place. And since part of the vapour will condense as it descends and heat be thereby disengaged, the equilibrium will be still further disturbed. It is in this way that all the more violent commotions of the atmosphere, gales, storms, hurri- (*Page* 225) canes, and tempests originate. J. K. Laughton lays too much stress (*Phil. Mag.*, 1867) on the condensation of vapour as the cause of wind. Winds are the simple result of differences of pressure, whether such differences be caused by temperature, or from the presence of aqueous vapour or from its condensation. (*Page* 232) An inquiry into the disturbing influences caused by evaporation and unequal temperature as compared with the surrounding land would be a valuable contribution to meteorology—such, for example, as a statement of the local and other causes by which the direction of the winds in January is N.E. at Christiania

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(*Page* 282), whilst at Skudesnes, Christiansund, and Hammerfest, the mean direction is S.S.E. For a theory of storms to be satisfactory, it must account for the saturation of the atmosphere with vapour, often over a most extensive region which must be considered as the necessary precursor of storms. How can we account (*Page* 283) for the first part of the course of the West Indian hurricanes, which is at right angles to the prevailing trade winds of that region? Dr. E. Lommel has shown (*Page* 321) that in passing through different thicknesses of vapour, the blue rays of light are first absorbed, then the yellow, and finally the red. When the sun is high in the heavens the thickness of the vapour screen between the sun and the eye is (*Page* 322) not sufficient to produce any perceptible action on the rays of light, which consequently appear white; but as the sun descends to the horizon, the thickness of the vapour is greatly increased, and at sunset it is calculated that the light of the sun has to pass through two hundred miles of air in illuminating a cloud a mile above the earth. Hence, as the rays fall more and more obliquely on the clouds, they appear successively yellow, orange, and finally red. The varied colours of the sun at sunset are caused by the clouds appearing at different heights and in different parts of the sky, so that various thicknesses are interposed between them and the sun. At dawn the clouds first appear red, but as the sun rises higher the yellow light ceases to be absorbed, and the clouds appear orange, yellow, and finally white. It is evident that a high red dawn may be regarded as prognostic of settled weather, because the redness seen in clouds at a great height, while the sun is yet below the horizon, may be occasioned by the great thickness of the vapour screen through which the illuminating rays must pass before reaching the clouds, and not to any excess of vapour in the air itself. But if the clouds be red and lowering in the morning, it may be accepted as a sign of rain, since the thickness (*Page* 323) traversed by the illuminating rays being now much less the colour must arise from an unusual amount of vapour in the vesicular state and in the state intermediate between the vesicular and the gaseous, when the yellow and red rays (*Page* 325) pass. The time of diminution of atmospheric polarisation occurs in the earlier part of the day, when vapour is carried by the ascending currents into the higher regions of the atmosphere by which the cumulus cloud is formed, and no doubt higher up invisible crystals are deposited similar to those of the cirrus; and the period of increase occurs towards evening when the temperature of the lower (*Page* 326) stratum of air is falling, and the ascending currents having ceased, the cumulus clouds are dissolving and the quantity of invisible crystals likewise diminishing. Thus the maximum of polarisation occurs at that time of the day when the air is least encumbered with the invisible crystals of ice and the minimum when the crystals are in greatest abundance. From the above results, especially those showing the influence of the different state of the aqueous vapour of the air on its polarisation, we see the importance of this property of the atmosphere as a branch of meteorology; when the subject has been more widely observed and the law of its modification by the presence of aqueous vapour is more accurately known, it is probable that the knowledge may be turned to excellent practical account, in giving the earliest indication of the commencement of the saturation of the air in the upper regions, and inferentially of the approach of storm and of the rainy season (*Page* 331) within the tropics. If, after an unusual prevalence of S.W. wind, the N.E. wind should set in, it is probable that easterly winds will prevail. If the season be summer, the weather will become dry, warm, and bracing, particularly if the (*Page* 332) wind be E. or S.S.E. If easterly winds preponderate largely above the average in spring, the summer is likely to be characterized by S.W. winds with much rain and moisture; but if easterly winds nearly fail in spring they are likely to prevail in summer, bringing in their train dry, warm, bracing weather, clear skies, and brilliant sunshine. Sir John Herschel, in his 'Familiar Letters,'

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states that the moon has a tendency to clear the sky of cloud and to produce not only a serene but a calm night when so near the full, as to appear round to the eye. William Ellis examined the records at Greenwich from 1841 to 1847, and shows that such a striking effect does not exist. The popular opinion probably arises (*Page* 333) from the circumstance that the clearing of the sky near the time of full moon arrests the attention, whereas the clearing of the sky when the moon is not present is less likely to be noticed. Park Harrison has shown that shortly after full moon there is a tendency to dispersion of cloud, which though not very marked is yet very appreciable. Dr. Arthur Mitchell, in his 'Prognostics,' states that the farmers of Berwickshire say that when a long strip of cloud they call a salmon or Noah's Ark stretches in an E. and W. direction it is a sign of stormy weather, when in a N. and S. direction it is a sign of dry weather, or, as a weather saw has it—

'North and south the sign o' drought,
East and west the sign o' blast.'

When the cirrus cloud stretches from north to south, or more correctly from N.W. to S.E., atmospheric pressure is at the time, at least, in regions immediately surrounding Great Britain at the normal height, and there being thus no disturbance indicated, drought or settled weather may be looked for as the barometric pressure in Europe is about the average. But when the cirrus stretches in bands lying E. or W., or from S.W. to N.W., there is great atmospheric disturbance indicated pointing to a system of low pressure somewhere to the W. or S.W., from which a column of moist air is ascending and flowing as an upper current over Great Britain, and from experience we know that this current will ultimately prevail lower down, saturating the air as it descends in preparation for the storm which is advancing. The pocky cloud described by Dr. Clouston is stated to be followed invariably by a storm in about twenty-four hours. Its lower edge must be well defined, for a similar cloud with the lower edge of the festoons shaded away is followed by rain only. This cloud is probably caused by large volumes of saturated air forcing their way through drier and colder air, the form of this cloud suggesting moist air diffusing itself horizontally or from above, just as the formation of the cumulus indicates diffusion upwards. If this supposition be correct it shows the moist warm current to be of greater strength than usual, and a sudden commingling of air currents, differing widely in temperature and degree of saturation.

Buchan, A. *Journ. Scot. Meteorol. Soc.*, vol. ii. (1869), No. for October 1868 (*rvp*).

(*Page* 208.) Of the causes which render the atmosphere specifically lighter, and therefore lower the readings of the barometer, may be stated an excess of vapour over a restricted region, or the withdrawal of vapour from the atmosphere where it is condensed into rain or snow. Observation indicates that the greatest quantity of vapour at any place occurs immediately in front of a storm, the amount increasing as the barometer falls ; and that immediately after the storm has passed, or as soon as the rear of the storm begins to advance over a place, the quantity of vapour rapidly, and in some cases suddenly, diminishes. Now since air when it contains a (*Page* 209) considerable amount of vapour is specifically lighter than air which contains less, there is presented in the front part of storms, as compared with what prevails in contiguous regions, a disturbing cause, which, by making the whole mass of air lighter, necessitates an ascending current. Charts show that in storms the centre of the clouded and rainy region approximately corresponds with the space of least pressure, or to state it more accurately, it lies a little to the east of the place where barometers are lowest. When vapour is condensed into drops which fall as rain or snow, its pressure is withdrawn from the air ; and, for a time, a diminution

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of pressure proportional to the amount of vapour abstracted is the consequence. But in the act of condensation latent heat is given out, which, by passing into the surrounding air, maintains a higher temperature in the ascending currents than could otherwise hold good. Thus the tendency of cloud and rain is to lower the (*Page* 200) barometer, and so bring about the disturbance of the atmosphere which we see prevailing everywhere in storms.

F. R. H. *Symons's Meteorol. Mag.*, vol. iii. (*rsp.*)

(*Page* 102.) While we were in Abyssinia—February, March, April, and May—the sky was invariably clear from dawn to noon; but at some time during the afternoon, in the later part of the season, clouds appeared in the sky, and this occurred with a most remarkable punctuality. It was evident to us that at the same place the phenomenon would occur day after day at the same time within an hour or so. There was often mist at dawn, but this mist was soon dispelled by the sun, and only precipitated at all on three occasions. This would be merely a local accident, and may be neglected. But the daily punctuality of the gathering clouds from which we often got a hail or rain shower could not pass unnoticed. This was no peculiarity of the year we were there, for mention of rain frequently occurs in the statements of travellers over the same ground at the same time of the year, and almost invariably towards the end of the day's march, which would naturally be between 3 and 6 P.M. While we were along the Eastern Highland I believe the wind was constant from E.N.E., or N.W., although it was often deflected by the hills and valleys. This being the case, of course it brought with it from the lowlands, or perhaps even from the sea, vapour, which would be precipitated on striking against the lofty mountains. Hence the punctuality and also the reason of rain not falling in the morning. For during the night the evaporation would not take place in any considerable quantity. Perhaps it would be possible to calculate from whence the major part of the vapour came by noting the speed of the wind and the time of the arrival of the vapour which formed cloud on striking the mountain tops.

Gritton, F. B. *Symons's Meteorol. Mag.*, vol. iii. (*rsp.*)

(*Page* 106.) Sir J. Herschel, in *Good Words* for 1864, says that a clear sky and a serenity of weather at night are the usual accompaniments of the period of full moon, a tendency of which we have assured ourselves by long-continued and registered observations. (Editorial. Ellis finds from observations made every two hours day and night at Greenwich during seven years, 1841-47, that Herschel's theory is unsupported. Arago says, 'La lune mange les nuages,' and our sailors say, 'The full moon eats up the clouds."

Luck, Richard. *Symons's Meteorol. Mag.*, vol. iii. (*rsp.*)

(*Page* 106.) I have noticed in North Wales that before a coming gale of wind the light clouds are, especially soon after sunrise, brilliantly illuminated with gorgeous orange colour. What is the connection between them?

Lyell, Sir C. (*B.* 1868, 5.)

(*Page* 496.) Peat only grows in moist places having a sufficiently low temperature.

Mann, R. J. *Journ. Roy. Geog. Soc.*, vol. xxxvii. (1868) (*rs*).

(*Page* 57.) The summer in Natal is a season of very frequent cloud. The summer heat is tempered by cloud screens and constant evaporation. The winter is a season of almost constant sunshine. At the Cape of Good Hope the summer is dry (*Page* 58) and the winter wet. Almost every day in summer gets cloudy soon after noon, and the clouds continue to shroud the sky and screen the ground until far into the

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night, when the sky clears. The mean humidity at Maritzburg at 9 A.M., based on (*Page* 63) eight years' observations, was 71·2; at 3 P.M., 60·1; and at 9 P.M., 8·34; mean for the year 70·8.

Raimondi, Ant. *Journ. Roy. Geog. Soc.*, vol. xxxvii. (1868) (*rs*).

(*Page* 121.) The town of Ayapata in Peru is subject to neblina, or mist, generally towards the evening. It is so dense that objects are not to be distinguished a few paces off. Nearly all the towns situated on the eastern slope of the great chain, and between 8,000 and 12,000 feet above the sea, have this visitation of the neblinas. The phenomenon is owing to the currents of air being in one direction during the day and in another during the night. In the morning the elevated portions are free from mist, but the lower and hot parts are then filled with a dense stratum o vapours. The elevated portions of land being at these hours first exposed to the sun are heated, and a current of air from the lower and hot parts is thereby caused, and the vapours are carried from below upwards, and are dissolved in the higher regions owing to the sun having heated them. In the evening the atmosphere (*Page* 122) becomes cold, and the vapours are condensed to form the neblinas. At night a down current is set up by the cooling of the lower regions, the mists fall as water, leaving the air clear.

Strachan, R. (*B.* 1868, 11.)

(*Page* 18.) The forecasting of cloudy, overcast, or clear sky must be rather a matter of shrewd guessing than an application of any definite rules.

Symons's Meteorol. Mag., vol. iii. (*rsp.*)

(*Page* 111.) The observer at Derby remarks on the absence of dew at that place during July arising from the dryness of the air, hot nights, and bleached condition of the grass (colour being an element in its formation).

(*Page* 118.) Fournet, in 'Commission Hydrométrique et des Orages,' 1866, notices that during stormy weather the S.W. winds arrive in the Rhône department almost saturated with vapour, which at times produce detached clouds around the mountain tops; at others banks of clouds, whose thickness varies, according to the intensity of the operating causes. In either case, owing to the currents of air, these clouds are so elongated that they may for distinction be called 'storm columns,' from their resemblance to columns of troops. Sometimes it happens that these bands are dissolved in passing from the mountains above the plains, while if the atmosphere is nearly saturated the elongation becomes considerable, and as our (*Page* 119) mountain tops are close together the celestial vault is carpeted with these columns, which remain parallel among themselves in a S.W. N.E. direction; lastly, if they are in a state of saturation, the vapour is condensed all along the bands; then also a very large dense and low stratus is formed, rain falls throughout, but traces of the column arrangement remain. Occasionally bands are formed from N. to S., when prolonged thunderstorms reign amid the peaks of our western mountains. Sometimes the phenomenon is confined to the S., sometimes to the N., and sometimes one or two bands alone are formed. Among the many interesting phenomena connected with these columns motion is but one; the unequal distribution of wind force, of lightning, and of vapour often appearing at intervals like waves, fully merit the notice of meteorologists.

(*Page* 194.) C. Meldrum, in his 'Meteorology of Port Louis,' in the Mauritius, notices that the curve of elastic force of vapour harmonizes exactly with that of temperature. The air is driest (63·6) at 1 A.M., and most humid about 3 P.M. (69·9). During seven years the air was never saturated, the nearest approach being 96·7 on August 21st, 1860. He refers to the double maximum and minimum of atmospheric pressure and to Dove's explanation. But he finds that at Mauritius the

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pressure (exclusive of the assumed vapour pressure) has a progression similar in all respects to that of the total pressure. Therefore, the phenomenon in question cannot be accounted for by the direct action of the vapour pressure. The nights (*Page* 195) and mornings are comparatively cloudless; towards 10 A.M. the clouds gather; by 2 P.M. it is often wholly overcast, and in the evening clear again. The mean amount of cloud is 4·7.

1869.

Brumham, G. D. *Symons's Meteorol. Mag.*, vol. iv. (*rsp.*)

(*Page* 56.) The position of the moon in the equator with regard to our [British] meridian has an important influence on drought. The rules are:—1. When on any day between the middle of March and the middle of September the moon reaches perigee or apogee in the afternoon within about an hour (say seventy minutes) of the time she comes to our meridian (and here I may say that the southing must occur in the afternoon, or at any rate at not more than twenty minutes after midnight) a long period of deficient rainfall will occur about that time or set in a few days afterwards. 2. In any year when lunar perigee occurs entirely or very frequently (*Page* 59) in south declination, if the moon crosses the equator on some day between March and October, within fifteen minutes of her southing, a long period of drought will set in (if it has not already commenced) shortly after the day when these latter phenomena occur. [A table is given of all the instances which have occurred of these two laws since 1833, with descriptions of the weather which was associated with them in South-east England.] When the sun reaches perigee within forty minutes of noon or midnight, the succeeding summer has always several months of very dry weather, and the rainfall of the period from March to September inclusive is always below the average. [All the instances which have occurred since 1833 are given.] The foregoing rules appear to be very infallible.

(*Page* 59.) According to the law, fine weather for harvest should set in soon after August 9th, and be dry for a long period. There should also be a month of deficient rainfall in the latter part of May.

[These notes, of course, refer to rainfall, but as they indirectly indicate dryness of the air they are entered here.]

(*Page* 88.) I did not regard the slight deficiency of rainfall noticed by Mr. Ryves as evidence of drought. There may be drought with an average rainfall, as by drought is meant a number of days in succession without rain. My rules refer to (*Page* 89) my district, and are correct for it. I do not know how other districts may be affected by them.

(*Page* 107.) I should have mentioned that in 1868 lunar perigee occurred in our meridian on March 5th. This may have inclined the weather to drought.

(*Page* 108.) There are other causes of great drought, such as great heat. The principle of uniformity with regard to the moon's positions near the equator (in December, January, April, or May) appears to cause a high summer temperature, and in that way to influence the rainfall. For instance, on April 20th, 1868, the moon at midnight was 0°45′ north of the equator, and on May 3rd she was 46′ south of the equator at the same time. The period of great heat and drought which set in about the end of April appears to have been caused by this uniformity. The instances that have occurred since 1766 are rare, but in every case great heat and drought accompanied the lunar phenomena. 1788, 1800, 1807-8, 1818, 1826, 1842, 1859, and 1868 were the only years in which this particular lunar uniformity occurred, and each year gave us a summer of great heat and drought. In 1846, 1857, 1859, and 1868 another kind of lunar uniformity occurred, and these years also gave us intense heat and much dry weather.

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Buchan, A. *Journ. Scot. Meteorol. Soc.*, vol. ii. (1869), No. xxiv., October 1869 (*rvp*).

(*Page* 342.) In Scotland the monthly curve of lightning without thunder roughly (*Page* 343) follows the curve of relative humidity.

Griffith, C. H. *Symons's Meteorol. Mag.*, vol. iv. (*rsp.*)

(*Page* 40.) Which is the correct way of computing mean daily humidity? By using Glaisher's tables at low temperatures I sometimes get a much greater mean temperature of the wet bulb than of the dry. Thus on October 24th I had—

9 A.M.		3 P.M.			
Dry Bulb.	Wet Bulb.	Dry Bulb.	Wet Bulb.	Max.	Min.
45·6°	45°	55·4°	55·3°	60·2°	38·4°

Max. 60·2°
Min. 38·4 } range 21·8°
Sum. 2)98·6
Mean 49·3
Corrn. from Table 0·9
48·4 mean from max. and min.

	Dry Bulb.		Wet Bulb.	
	9 A.M.	3 P.M.	9 A.M.	3 P.M.
	45·6°	55·4°	45·0°	55·3°
Corrn. from Table III.	0·2	7·4	0·8	3·9
	45·4	48·0	44·2	51·4
	2)93·4		2)95·6	
	46·7 mean from dry bulb.		47·8 mean from wet bulb.	

Home, D. Milne. *Journ. Scot. Meteorol. Soc.*, vol. ii. (1869), No. xxiii., July 1869 (*rvp*).

(*Page* 313.) Baddeley says when whirlwinds are running about white patches of cirro-cumulus are frequently seen in the clear blue sky exactly resembling flakes of teasled cotton, having rotatory motions throughout, forming and then rapidly dissolving, or ascending with whirling motions in the upper regions.

Kesteven, W. B. *Symons's Meteorol. Mag.*, vol. iv. (*rsp.*)

(*Page* 179.) The dry bulb is generally from ·5° to 1·5° too low, owing to evaporation of moisture condensed on it from a very moist air.

Ryves, G. T. *Symons's Meteorol. Mag.*, vol. iv. (*rsp.*)

(*Page* 67.) Mr. Brumham's rules do not seem to be infallible. He regards ·03 in. ['3 in. Ed.] deficiency of rain as evidence of drought; and this rule should, but does not, apply to all places in the same meridian. In the summer of 1868 it was dry here, but in South Europe it was exceptionally wet and cold. At Rome we find June and July were wet and cold; August and September scarcely warm; November and December wet, cold, and foggy. The difference of meridian from Greenwich is not more than fifty minutes. Hence the moon was within fifty-five minutes of its southing at Rome, and the case was fairly within Mr. Brumham's rule. Scotland has the same meridian as England, yet we sometimes have extreme wet there, while South England is exceptionally dry.

Stewart, Balfour. *Symons's Meteorol. Mag.*, vol. iv. (*rsp.*)

(*Page* 153.) The amount of vapour present in the air affects the skin of the human body and the leaves of plants; but I am not aware that it has yet been determined by the joint action of naturalists and meteorologists what is the precise physical function which expresses proportionately the effect of moisture upon animal and vegetable life. Is it simply relative humidity? or does not a given relative humidity at a high temperature have a different effect from that which it has when the temperature is low? I will, however, here consider the matter from the physical science point of view. As such it is one of our objects to ascertain the distribution

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and laws of motion of the dry and wet components of our atmosphere; and it cannot be denied that at the present moment we are in very great ignorance of these laws. As we cannot trace the motions of individual particles of air, or vapour, we must arrive at it indirectly, by frequently ascertaining the amount present at any one station at any moment. The best way of measuring the amount is the mass of vapour present in a cubic foot of air. With regard to the motion of the atmosphere, and of the vapour, we can gauge the mass of air and the mass of vapour passing a station horizontally. We have no means of getting at the vertical motion, and we (*Page* 154) must detect this indirectly. We ought also to determine the production or consumption of the vaporous element of our atmosphere as it passes from place to place. This might be done could we keep an accurate account of the evaporation and the precipitation; but this would be a very difficult operation. To recapitulate we can now determine—1. The mass of vapour actually present at a station from hour to hour. 2. The mass that passes a station in one hour going east and west. 3. The same going south and north. There are wanting 4. The vertical component of the motion of vapour. 5. Its production or consumption as it passes from place to place. These deficiencies may be, to some extent, overcome by the following considerations. First, the atmosphere moves as a whole when it moves, the dry and moist air moving together; secondly, dry air is neither capable of production nor of consumption, but always remains constant in amount. To illustrate this part of the subject, let it be supposed we wish to investigate the vertical motion of the atmosphere at a certain station. Make this station the imaginary centre of a circle, the circumference of which may be supposed to be studded with other stations at sufficiently frequent intervals so that we can tell hour by hour how much dry air passes in towards the centre, and how much passes out away from it. Suppose more air passes in than passes out. But if we find a diminution in the stock of air at the centre, some must pass upwards and carry the vapour with it. Now as to the vapour. The hygrometric quality of the air may be represented by—

$$\frac{\textit{Mass of vapour in a cubic foot.}}{\textit{Mass of dry air in a cubic foot.}}$$

This quotient can only alter by evaporation, or by precipitation, or by mixture. The hygrometric quality of the air may perhaps be considered as a quality sufficiently constant to aid us in tracing the actual motion of the air. But besides this aid we may make use of it to enable us to tell the precipitation or evaporation. For instance, a very damp air in passing over a very dry country may be supposed to emerge less damp, having its hygrometric quality changed, and so with regard to dry air traversing a damp country, the change being in the opposite direction. Thus by actual observation of the quality of the air at the time of its reaching some particular tract of land or ocean, and at the time of its leaving it, we may possibly get much better observations of what goes on in the country, as far as this particular (*Page* 155) research is concerned, than if it were studded with gauges. Meldrum suggests that summaries should be given of the aggregate wind in definite directions, and Airy suggested that the phenomena could be best studied when the wind was constant in the same direction for a long period.

Stow, F. W. *Symons's Meteorol. Mag.*, vol. iv. (*rsp.*)

(*Page* 85.) The drought in 1868 began in April, and wet weather set in on August 6th. But Mr. Brumham claims it was dependent on the position of the moon on July 20th. This is like putting the cart before the horse.

Symons, G. J., and R. Field. *Symons's Meteorol. Mag.*, vol. iv. (*rsp.*)

(*Page* 132.) They notice the variable results given by the observers of evaporation, 11 in. in one case, and 48 in. in another, for the same year; and they

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condemn the method proposed by Daniell. The chief source of error is the abnormal heating of the water in the evaporators. They made a series of experiments on the canal of Burgundy in large tanks, and found the amount to be half that generally assumed. More reliable instruments are necessary.

Symons's Meteorol. Mag., vol. iv. (*rsp.*)

(*Page* 65.) Would it not be an advantage if a few observers would concentrate their attention on the character of the sky as indicative of weather? Clouds should (*Page* 66) be methodically observed and the observations reduced to a tabular form, as for instance, thus:—On left-hand page of a foolscap-sized book rule 16 columns for—1, date; 2, hour; 3, temperature; 4, barometer; 5, wind direction; 6, wind force; 7, rain; 8, amount of cloud; 9, forms of cloud; *a*, cirrus; *b*, cirro-cumulus; *c*, cirro-stratus; *d*, cumulus; *e*, cumulo-stratus; *f*, stratus; *g*, nimbus; *h*, scud. The (*Page* 84) proportion of sky occupied might be given as nearly as can be estimated. The colour of the sky is modified by the combination of three tints—viz., the blue, which is reflected by the particles of air; the black of space; and the white of the vesicles of fog and flakes of snow. The blue rays are darkened by the one, and lightened by the white of the vesicles of fog. When we ascend in the atmosphere we leave a great portion of the vesicles of vapour beneath us, so that while the rays reach the eye in less proportion, and the sky being covered with a lesser number of particles reflecting its light, the colour becomes of a deeper blue. For the same reason the blueness of the horizon is less intense than at the zenith. If the sky is paler in the open sea and in high latitudes than in the interior of the continents and in the neighbourhood of the equator, it must be attributed to the vesicles of fog.

Wild, H. (*B.* 1869, 12.)

(*Page* 294.) When objects in the distance are obscure and hazy, it is regarded as a sign of fine weather, but when they come out unusually distinct it is considered to be a sign of approaching rain. De la Rive's explanation is that the air is rendered opaque by the presence of dust and vegetable germs. When the S.W. winds blow the air becomes moist, the corpuscles absorb moisture, and being rendered heavier, fall to the ground, leaving the air more than usually transparent. Marshal Vaillant explains the difference by the greater or less prevalence of vertical air currents.

1870.

Ansted, D. T. *Physical Geography*, 4th Ed., 1870.

(*Page* 59.) Area of water is 145 million of square miles. Water area north of (*Page* 61) the equator equals 59 millions of square miles; south of the equator, (*Page* 150) 86 millions of square miles. The excess of evaporation above rainfall is (*Page* 238) directly or indirectly one of the most important causes of oceanic currents. The sun's heat reflected from the shining moon is absorbed by our atmosphere before it reaches the earth, and thus tends to disperse cloud, and produce (*Page* 271) coolness on the earth by allowing of increased radiation. When rain has recently fallen, it is often curious in mountain countries to watch the incessant and rapid formation of cloud over some small wooded patch of land, the moisture from the warm earth steaming into the chilled air, and being immediately converted into mist, which gradually accumulates until it breaks away and drifts to a distance, assuming a distinct cloud nature. It is equally curious to observe a narrow side valley in a mountain district, covered for hours together with mist and rolling cloud, while the larger and more open valley into which it opens has a perfectly clear sky. The cause of this is obvious. The lateral valley, enjoying less of the sun's rays, is colder than the more open valley adjacent; the air as it passes is

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therefore sucked up the side valley, and coming into the cooler temperature of its sides is at once condensed into mist. Such mist may often turn into cloud. The clouds below 10,000 feet are more massive than those above, and are more influenced (*Page* 272) by local causes. The quantity of vapour existing in the air in an invisible form depends on local temperature, and is probably at no time uniform over any considerable area, and certainly never the same for twelve hours together in the same place. It is found that when the temperature is 50° F. each cubic yard of dry air (about 168 gallons) can hold nearly 150 grains of water; at 32° F. (*Page* 273) only half this; and at 70° F. nearly double. Condensed vapour has a tendency to assume the form of the object by which it is caused. Thus, when mountains are present, a cloud seems to fix itself at the summit or on the sides of the mountain at a certain level, and there obstinately remain, as on Table Mountain and Mount Pilate. The warm wind loaded with moisture is chilled. The chill commences a short distance to windward of the object, and continues at a distance to the leeward of it, until the air is no longer affected by the cool surface it has (*Page* 274) been in contact with for a time. The cloud is a driving mist. At the equator Humboldt observed the general direction of cirrus clouds to be N. and S. (*Page* 279), but with us they seem more frequently N.W. and S.E. Clouds neither float in the air like boats, nor are they retained only for a short time, like feathers, by friction and resistance; nor do the particles of water in a cloud consist of hollow spheres with void cavities or with their interior filled with light gas. Neither is the water cloud like the cloud of incense that rises and for a time floats in air while disseminating its fragrance. The permanence of clouds is due to the vapour atmosphere being independent, and to the gases diffusing into each other, so that the (*Page* 280) heavier gases are held up by the lighter. The vapour may be set free without assuming a fluid form. It is possible that clouds are limited to air in motion, for it is quite certain that a cloud may appear in repose, even when violent and shifting winds are all around. The conversion of what may be called a dry cloud into a mist seems to be accompanied in all cases with electrical action. Owing (*Page* 285) to the unequal distribution of land in the two hemispheres, the aqueous vapour, which from the autumnal to the vernal equinox is developed to an immense extent in the southern hemisphere, returns to the earth in the other half of the year in the form of rain and snow. Immense physical force is exerted in the evaporation of water from the ocean. The total estimated rainfall is not much less than 200 millions of millions of tons. Hence about 7000 lb. weight of water are (*Page* 286) evaporated every minute, on an average, throughout the air from each square mile of ocean. The conversion of this into vapour, its conveyance through the air, and its recondensation involves an expenditure of force equivalent to the lifting of very much more than 1,500,000 millions of millions of pounds of water, one foot high per minute of time during the whole period. Besides evaporation from the sea, there is also a very large evaporation from the surface of the land. This is a fraction of the real amount of force exerted, for much of the water raised by evaporation falls back as rain directly into the ocean. It is a work going on incessantly, and one that has probably been going on at nearly the same rate during (*Page* 302) all time. By the drainage of land and the removal of forests, the conditions of a country are so far altered with respect to its rainfall and the moisture (*Page* 306) of the air, that the temperature becomes permanently affected. Cirrus clouds are often the first signs of coming wind and change of weather. In summer (*Page* 307) they announce rain, in winter thaw. When the round heaped clouds appear early in the morning they often gradually disappear as the day advances, and after noon the sky is clear; but when they come on after noon and increase towards evening, they generally terminate in rain. Among signs of fine weather, an early and heavy dew has often been noticed.

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Bidie, George. *Journ. Roy. Geog. Soc.*, vol. xxxix. (1870). Paper read January 25th, 1869 (*rsp*).

(*Page* 78.) In the shade of the dense jungle forest of Coorg there is a dense undergrowth of moisture-loving plants, such as cardamom, canes, areca, plantain, tree and other ferns, wild pepper, arums, and orchids. The rain in (*Page* 79) Coorg mainly comes from the S.W. monsoon, which is the S.E. trade wind deflected westerly by the diurnal rotation of the earth, and as this passes over an immense expanse of ocean ere it reaches the land, it becomes heavily charged with moisture in its course. The presence or absence of forests can have no appreciable influence on the amount of rainfall. At the same time, it must be stated that the natives of Coorg complain that of late years their country has become hotter and drier from want of rain, and that rice crops have been diminished or lost from a failure of water in streams that used to run throughout the year. These changes they attribute to the cutting down of forests on coffee estates. It is (*Page* 80) only since the advent of the European planters, or during the last twelve years, that felling of forests to any considerable extent has taken place in Coorg, and as the clearing has progressed in annual instalments of comparatively small extent, the results have crept on gradually. There can be no doubt, too, that the evil influences called forth by forest destruction do not attain their full force immediately, but go on increasing from year to year until they acquire a most disastrous power. The spots that have been selected as sites for estates are chiefly situated on the flanks and crests of low hills, the sides and bottoms of ravines, and the slopes and passes running down on the west side of the Ghats to the low country. Such localities are, as a rule, densely wooded, and being well supplied with springs, give rise to numerous small streams. In fact, they may be looked upon as the fountains of the river system of the country. The question then arises, To what extent are springs and streams in such situations dependent on the forests for their supply of water, and what will be the effect on them of its removal? Springs and small streams are fed by the water stored up in the earth during the rainy season. As the rain descends on natural forests, it is conveyed in various directions by the leaves towards the ground, and on reaching this is prevented from running rapidly off by the dense undergrowth of shrubs and herbaceous plants, and a carpet of dead leaves. Below this it encounters a layer of vegetable mould, which, having a great affinity for moisture, absorbs it like a sponge. As soon as the humus is fully saturated, it passes on what water may subsequently fall to the subjacent earth, and this process of percolation is in various ways aided by roots, which descend to great depths, perforating the densest subsoil, and even forming passages in rock. The quantity of water thus transferred to the depths of the earth and the reservoirs of springs is enormous, and when the dry season arrives the forest again plays an (*Page* 81) important part by husbanding and giving off gradually the subterranean supplies. As the water rises, it meets with many obstacles, preventing its collecting into streams and passing rapidly away. Although the quantity of water taken up and exhaled by trees is very great, a proportion of it is returned as dew or fog, and what is wafted away is fully compensated for by other advantages resulting from the presence of forest. The influence of shade in modifying evaporation is well illustrated by what happens in the coffee districts after the April showers, which herald the advent of the S.W. monsoon. On an estate freely exposed, a day or two of sunshine after a heavy fall will have rendered the soil quite dry and hard again, whereas on an estate under forest shade the ground will continue damp for a week or more. Although their insignificance might lead to their being overlooked, there can be no doubt that the mosses, lichens, and succulent herbaceous plants which abound in tropical forests are also of considerable benefit in retaining

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moisture, as during rain they absorb water like a sponge, and part with it again very slowly. It would, therefore, appear that there are numerous agents and conditions in natural forests favourable to the production and permanence of springs and streams which are not to be found in open ground, originally so or denuded of its trees by man. The facts thus elicited go far to prove that tropical forest is the *alma mater* of springs and streams. Various instances have been brought to my notice of springs and small streams having become quite dry since the forest was cleared away in their neighbourhood; while in numerous cases, those that used to be perennial only contain water now during, and for a short period after, the monsoon. Similar results have been found to follow the destruction of forests growing near the sources of streams in all parts of the world. Thus Palestine and other Eastern countries have been rendered desolate by the destruction of the forests that existed in them when they were so famous for their beauty and fertility, and in modern (*Page* 82) times many districts in France and America have had their water supply diminished, and fertile land converted into arid wastes, by the clearing away of woods around the head waters of streams. In a recent Mauritius paper it was stated that the culture of the sugar-cane had of late become precarious in the island, owing to the excessive dryness of the air and soil consequent on the cutting down of forests. For several years, too, the nutmeg trees of Singapore have been dying. A most graphic account of the disaster will be found in Cameron's 'Malayan India,' and judging from the information there given as to the cutting down of forests to make way for the nutmeg, and the manner in which the trees died, there seems every reason to believe that their death was accelerated, if not entirely induced, by the reduction of humidity resulting from extensive clearing. The effect of forest-clearing and burning of the undergrowth is to make the soil friable and easily removed, so as to leave the barren stony subsoil (*Page* 85) exposed. The rainfall drains away rapidly. The plants which spring up in neglected clearings are such as grow in hot, dry situations. Forests reduce the temperature of the air chiefly by transpiration. The amount of water exhaled in this way is enormous, a sunflower having been found to give off from 20 to 30 ozs. daily. Although a tree under certain (*Page* 86) conditions will absorb moisture from the air, still the amount thus withdrawn is as nothing compared with what it gives off by transpiration. By a beneficent arrangement, too, the amount of exhalation increases within certain limits in exact ratio with the heat and dryness of the air, and thus the severity of the hot season is partially mitigated. Plants in the immediate neighbourhood of forest, even although enjoying no shade, show by the colour and luxuriance of their leaves that they are living in moister earth and air than those at a distance. As regards the soil, it is always very much damper in forests than in open ground. Forests are of great benefit to cultivated plants in their neighbourhood by promoting the deposition of dew, and causing fog. They also obstruct the passage of drifting fogs, and so make them part with some of their moisture; and when a dry, scorching wind sweeps over a damp wood it is moistened, and rendered much less hurtful to vegetation. Again, when a cultivated valley lies at the base of a forest-clad hill, the moist stratum of air above the trees rolls down the slope to it in calm nights, covering each leaf and blossom with copious dew. That the cutting down of forests in Coorg has rendered both the earth and air there drier is clearly shown by many plants perishing that used to flourish during the dry season, and by other remarkable changes. The most (*Page* 87) remarkable change produced by forest obstruction on vegetation has been the increase in species that formerly grew in hot and barren situations in the province. Thus we have in clearings several kinds of ficus, two macarangas, *Sponia Wightii* (charcoal tree), two solanums, *Clerodendron infortunatum*, *Calli-*

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(*Page* 88) *carpa caria*, several grasses, etc., all naturally inhabitants of pasture land. At the same time, several moisture-loving plants, such as ferns, aroideæ, canes, wild plantain, cardamom, etc., have become much less common, or have disappeared in various tracts. The *Solanum rubrum* has become common in some places. *Physalis Peruviana*, an exotic, has also increased in a wonderful manner, growing spontaneously in clearings all over the country. The plant that has been most influenced by forest destruction is the White Weed, or *Ageratum Cordifolium*, which pursues the footsteps of the planter wherever he goes, springing up all over (*Page* 89) his clearings. Forests on the crests or slopes of hills on which important streams arise should always be carefully preserved, and the banks of streams should always, to the distance of twenty or thirty yards on each side, be left under wood, as its presence serves to keep up the water supply in the dry season. The rice lands in Coorg are very peculiar, being long, narrow, winding patches, surrounded by low forest-clad hills, from which they derive their water supply. Forest in the upper end of ravines should also be preserved, as it invariably gives birth to springs and streams.

Chambers, C. *Symons's Meteorol. Mag.*, vol. v., November. Paper read to the British Association (*rs*).

(*Page* 168.) Two distinct causes are assigned for the larger quantity of rain in the lower gauges: first, that damp air transferred by the agency of winds from a warm to a cold district, finds the latter region colder, not in the upper strata only, but also in the lower, and in cooling, has its vapours condensed as well in the lower strata as in the higher. Consequently a rain-gauge placed at any given elevation will catch rain, amounting to the sums of the condensations above it, and, therefore, the lower a gauge is placed the greater will be the quantity of rain it receives. The second cause suggested supposes the particles in the air to be susceptible of electrical induction, and consequently, to be electrically polarized by induction from the ground, which is known to differ in electrical tension at all times from the atmosphere above it. This polarization of the particles of vapour gives rise to mutual attractions between them, and to their successive coalescence forming raindrops, and the attractions being strongest near the ground the coalescence will there be most rapid. Consequently, not only should more rain be caught by a gauge at a lower elevation than by one at a higher, but the rate of variation with heights of the quantities received should be more rapid near the ground; and this is in accordance with observation. The second cause also seems to explain the greater fall of rain over forest land; and also, in part, the greater fall in mountainous districts, over land without trees, and over plains.

Compton, T. A. *Symons's Meteorol. Mag.*, vol. v. (*rs.*)

(*Page* 22.) At Bournemouth, on February 12th, at 2 P.M., the dry bulb stood at 27·5° Fah., and the wet at 23°, indicating a humidity percentage of 28.

Dines, G. *Evaporation. Symons's Meteorol. Mag.*, vol. v. (*rs.*)

(*Page* 70.) As April has been very favourable for evaporation experiments (with a total rainfall of 0·4 in. on five rainy days), I send you a description of my gauges, with the amount of evaporation from each. No. 1 is 18 in. in diameter, and can be measured to $\frac{1}{100}$ in. It was observed daily every morning. The results were as follows:—

No.	Inches.	No.	Inches.	No.	Inches.	No.	Inches.	No.	Inches.
1	·012	7	·120	13	·140	19	·146	25	·149
2	·078	8	·117	14	·148	20	·173	26	·168
3	·042	9	·153	15	·093	21	·211	27	·213
4	·091	10	·132	16	·109	22	·205	28	·120
5	·090	11	·041	17	·128	23	·251	29	·064
6	·094	12	·087	18	·165	24	·208	30	·068

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The temperature of the water varied from 32° to 77° Fahr., that of the water in the river Mole from 39° to 60·3°. No. 2 is 8 in. in diameter, 6 in. deep, and exposed to the air. The measurements are taken with a vertical float and an attached vernier. No. 3 is 5 in. in diameter, 2½ in. deep, and exposed to air. No. 4 is 4 in. in diameter, 2 in. deep, and fixed at the top of the thermometer-stand. The (*Page* 71) outside is covered with felt to keep the temperature more even. No. 5 is a 5-in. Casella rain-gauge. The total evaporation during the month was respectively—

No.	Inches.	No.	Inches.	No.	Inches.	No.	Inches.	No.	Inches.
1	3·816.	2	5·660.	3	6·710.	4	6·370.	5	4·650.

Nos. 2 and 3 were placed by the side of the 18-in. gauge, about 4 ft. from the ground. No. 5 stands by the side of the other rain-gauges, one foot above ground. In Nos. 1, 2, 3, and 4 the water was generally kept ½-in. below the edge of the vessels. No. 5 was rather lower, or about 1 in. The evaporation from No. 3 was 76 per cent. greater than that from No. 1. Had the evaporation during the day only been given, the difference would have been far greater, as whenever the opportunity of observing the gauges twice during the twenty-four hours has occurred, the evaporation from the smaller gauges during the night has been much less than from the larger ones. In 'British Rainfall' 1869, p. 156, it is said that the accuracy of an evaporation is largely dependent on its capabilities of retaining the temperature of the contained water at, as nearly as possible, that of large volumes of water, such as reservoirs, rivers, and ponds, which statement I endorse. One experiment showed this. From water at a temperature of from 90·7° to 85° the evaporation was at the rate of ·015 in. per hour; from water at 62°, the temperature of the room, it was ·0031 in. per hour. During May the evaporation from my gauges was :—

No.	Inches.	No.	Inches.	No.	Inches.	No.	Inches.	No.	Inches.
1	4·927.	2	5·621.	3	6·542.	4	8·111.	5	5·340.

The positions of Nos. 2 and 3 were varied, being sometimes in the earth, and sometimes in water, nearly to the level of the upper rim. The temperature of the water in gauge No. 1 varied from 33° to 84°; that of the water in the river Mole 46° to 66·8°. (See Notes, 1786, Williams, Exp. 2.)

Dines, G. (*B.* 1870, 8.)

(*Page* 79.) Paper on evaporation and evaporation-gauges, read before the Meteorological Society of London. His conclusions are: 1. The greatest cause of evaporation is the movement of the air. 2. Whatever tends to increase the temperature of the air increases evaporation, and *vice versâ*. 3. That which tends to lessen the temperature of the dew-point increases evaporation, and *vice versâ*.

Erskine, St. Vincent W. *Journ. Roy. Geog. Soc.*, vol. xxxix. (1870). Read June 14th, 1869 (*rs*).

(*Page* 245.) On the Bembe the sky was generally clear towards early morning, and until 10 or 11 o'clock; but after that, bank after bank of clouds would blow up from seaward and completely obscure the sun.

Fuller, F. *Symons's Meteorol. Mag.*, vol. v. (*rs.*)

(*Page* 59.) A self-constituted instrument similar to Snell's aneroid hygrometer may be seen at the Charing Cross lift, which is regulated by a thick rope passing along its whole length. The porter in charge will tell you any day what the weather is going to be by the slackness or tightness of the rope.

Poey, A. (*B.* 1870, 14.)

(*Page* 382.) He says, each country, according to its geographical position, has its

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own type of clouds. Here the cirrus predominates, there the cumulus, elsewhere such and such forms, which do not exist in other places.

Somerville, M. (*B.* 1870, 17.)

(*Page* 218.) The ocean covers three-fourths of the earth's surface. There is three times more land in the north than in the south hemisphere. The superficial extent of the ocean is probably unaltered. The difference in the composition of (*Page* 223) sea water depends upon local circumstances. Thus the ocean contains more salt in the south than in the north hemisphere, which is supposed to arise from the S.E. trade-winds blowing over a greater expanse of water than the N.E., and causing a greater evaporation. The sea is heated at its surface by the (*Page* 229) direct rays of the sun, which produce a strong and rapid evaporation, especially in the tropical seas of the ocean. It is computed that 186,240 cubic miles of water are annually raised from the surface of the globe in the form of vapour, chiefly from the inter-tropical seas. The enormous quantity of water thus carried off by evaporation in the warm seas disturbs their equilibrium, which is (*Page* 252) restored by means of the currents. There is probably not a drop of water on the earth's surface that has not been borne on the wings of the wind. (*Page* 254) Jets of steam of high tension are frequent in volcanic countries. (*Page* 296) Many salt lakes may be remnants of the ancient ocean left in the depressions of its bed as the waters retired when the continents were raised above its surface. There are more lakes in high than in low latitudes, because evaporation is much greater in low than in high latitudes, and in this respect there is much analogy between the northern plains of the two principal continents. By the (*Page* 306) constant evaporation of their surface lakes maintain the supply of humidity in the atmosphere so essential to vegetation. The evaporation over the (*Page* 314) surface of the ocean is so great, that were it not restored, it would (*Page* 316) depress its level about five feet annually. In consequence of the unbounded extent of the ocean in the south, the air is so mild and moist that a rich vegetation covers the ground, while in the corresponding latitudes in the north the country is barren from the excess of land towards the Polar Ocean, which renders the air dry (*Page* 319) and cold. [See statement at p. 421.] The aqueous vapour is most abundant in the torrid zone, and, like the heat on which it depends, varies with the latitude, the season of the year, the time of the day, the elevation above the sea, and also with the nature of the soil, the land, and the water. The N.E. trade-wind (*Page* 323) arises from the south side of the calm belt of Cancer, and a S.W. wind from its north side. They leave the calm belt loaded with vapour, which is precipitated as they pass into a colder zone. These S.W. winds do not obtain that enormous quantity of vapour while crossing the Atlantic, for they probably give by rain as much as they receive by evaporation; therefore it can only come from the south hemisphere. The S.E. trade-winds carry the moisture evaporated from the great southern ocean to the equator; there they rise into the higher regions of the atmosphere, and blow as an upper current in the calm belt of Cancer; and now, being chilled, they sink down and come out from the north side of the calm belt as the rainy S.W. winds of the extra-tropical north hemisphere. The same reasoning (*Page* 326) applies to the calm belt of Capricorn. The influence of the heated great plains is felt 1,000 miles or more at sea. Thus, though the desert of Gobi and the sun-burned plains of Asia are for the most part north of the latitude of 30°, their influence in producing monsoons is felt south of the equator. In like manner the Central American monsoons of the Pacific are caused by the heated plains of Texas and Utah; those of the Mexican Gulf by the dry lands of New Mexico; and the monsoons of the Gulf of Guinea by the sandy deserts of Africa. Similarly, also, the heated interior of Australia causes an indraught of air during the time the sun is

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south of the equator, and a N.W. monsoon, caused by the reversal of the S.E. trades (*Page* 334), brings rain to all the north coast. A thick lurid appearance, with dense (*Page* 338) masses of cloud on the horizon, is a harbinger of typhoon. There are about twenty-five millions of square miles of sea in the north hemisphere, and nearly seventy-five in the southern; besides, the zone of the S.E. trade-wind is much greater than the northern, and covers three times as much water, yet the mean annual amount of rain in the northern hemisphere is probably about 37 in., and 26 in. in the southern; for the vapour from the great reservoirs at the equator and the southern hemisphere is wafted by the S.E. trade-wind in the upper regions of the atmosphere till it comes to the calms of Cancer, where it sinks down and becomes a S. and S.W. surface-wind, and then the condensation begins that feeds all the great rivers of the world. Rains, fogs, etc., are much more frequent and irregular on this side of the equator than on the other. Throughout all the countries in the north hemisphere, where observations have been made on the variations of atmospheric moisture, it appears that the air contains absolutely less vapour in January than in any other month of the year, yet at that (*Page* 339) time there is the greatest dampness to our sensations; while in July the air feels driest, although, on account of the heat, evaporation is the greatest. In summer the dew-point is much further below the temperature of the air than in winter, hence the air is drier. When the moisture is abundant and the tension great, which is often the case before rain, the air is very transparent, and distant objects appear nearer, and all their details are more distinctly seen; from this circumstance, the clearer view of distant mountains and headlands indicates wet (*Page* 340) weather. Dew is very abundant on the shores of continents, but it is not deposited on small islands in the midst of large seas, because on them the difference between the temperature of the day and night is not sufficiently great. There is (*Page* 341) very little dew in the interior of continents, except near lakes and rivers. Fogs rarely occur at sea between the parallels of 30° N. and S., that is, over half the globe. The cloud region of the trade winds is from 3,000 to 5,000 feet high, and it is generally higher over the sea than over the land for the same amount of vapour in the wind. In the north temperate zone the cloud region is high over the land and low over the water; and, as a rule, the further inland, the drier the air (*Page* 344) and the higher the cloud region. The equatorial belt of calms lies mostly north of the equator in the Atlantic; in it the winds meet, and, being highly elastic, they ascend, till, by the cold of the atmosphere, they are condensed into the cloud ring which surrounds the earth and overhangs the belt of calms, but leave the sky clear on both sides. New vapour is continually rising to the under-surface of this cloud ring, is condensed, and falls in constant rains. These rains fall during the day, and morning and evening are free from storms. In the belt of calms, the air, being greatly heated by the vertical rays of the sun, ascends, drawing with it the whole mass of vapour the trade winds have brought with them, and which has been greatly added to by the rapid evaporation from the belt of calms. This vapour is condensed as it rises to the line of junction of the lower and upper trades. In countries between 5° and 10° S. and N. there are two rainy and two dry seasons; one which lasts four months, and another which lasts two. Within the tropical belt of calms and rains one period of the year is extremely wet and the other extremely dry, the change occurring at the equinoxes. The monsoon region furnishes another instance of the effect of mountain chains upon the fall of rain. Throughout the whole of that region it is not the sun directly, but the winds, that regulate the periodical rains. That region extends from the east coast of Africa and Madagascar across the Indian Ocean to the north districts of Australia, and from the tropic of (*Page* 346) Capricorn to the face of the Himalaya, the interior of China to Corea, and even round the north of Siberia. In the south hemisphere the rainy

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season corresponds with the N.W. monsoon, and the dry with the S.E. The extent of country on which rain seldom or never falls is five-and-a-half million of (*Page* 347) square miles. The prevailing winds are deprived of their vapour by condensation before arriving at the rainless deserts. Between the tropics it rains rarely during the night, and for months together not a drop falls; while in the temperate regions it often rains in the night, and rain falls at all (*Page* 352) seasons. The atmosphere, where rarefied, absorbs all the colours of the sun's light, except the blue, which is its true colour. In countries where the air is pure the azure of the sky is deep; it is still more so at greater elevations, where the density of the air is less, and its colour is most beautiful as it gradually softens the outlines of the mountains into extreme distance, or blends the earth with the sky. When the sun is near the horizon, the atmosphere, on account of its superior density, absorbs the violet and blue, and leaves the yellow and red rays in (*Page* 353) excess; that property, together with the refractive power of the aqueous vapour, which is most abundant near the earth's surface, gives the roseate hue to the early morning, and the gold and scarlet tints to the closing day. The blending of these colours with the blue above produces the beautiful vivid green so frequently seen in warm countries. The last reflected rays of the setting sun are red. The (*Page* 357) electrical state of the air arises from evaporation, condensation, and chemical changes, but the water evaporated must contain matter susceptible of (*Page* 376) chemical action during evaporation. The greater part of the land is (*Page* 381) clothed with vegetation. The periodical phenomena of the appearance of the first leaves, the flowering, the ripening of the fruit, and the fall of the leaf, depend upon the annual and diurnal changes of temperature and moisture, and succeed each other with so much harmony and regularity that, were there a sufficient number of observations, lines might be drawn on a globe approximately indicating lines where the leaves of certain plants appear simultaneously, and illustrating the other phase of vegetation. The gentianella, veronica, and other plants close their blossoms on the approach of rain. Since (*Page* 383) the constitution of the atmosphere is very much the same everywhere, vegetation depends principally on the sun's light, moisture, and the mean annual temperature or heat of summer. Where rain does not fall the soil is unfruitful, but where moisture is combined with heat and light, the luxuriance of the vegetation (*Page* 389) is beyond description. Mosses are found everywhere in damp situations. (*Page* 393) The labiates are remarkable for their aromatic qualities and love of dry (*Page* 421) situations. Beyond Kerguelen Land and Terra del Fuego not a lichen covers the rocks. In the Arctic regions no land has been discovered destitute of (*Page* 426) vegetable life. Rice requires excessive moisture, and a temperature of (*Page* 436) 73·4°. Each soil has its own kind of insects, whether dry or moist, etc. As the rainy and dry seasons within the tropics correspond to our summers and winters, insects appear there after the rains, and vanish during the hot months; the rain, if too violent, destroys them; and in countries where that occurs there are two periods in the year in which they are most abundant, one before and one after the rains. Culex pipiens passes two-thirds of its existence in water. They swarm (*Page* 460) in the Arctic regions. In hot countries reptiles fall into a state of torpor (*Page* 461) during the dry season. Batrachians are aquatic in their early stage. (*Page* 462) Frogs are amphibious. Toads frequent marshy, damp places. Newts (*Page* 463) are aquatic. In sterile, open countries the proportion of venomous snakes is greater than in those that are covered with vegetation. All the crocodiles (*Page* 466) are amphibious, living in rivers or in their estuaries. Alligators are (*Page* 489) most numerous in the estuaries of great rivers. Monkeys chiefly occur (*Page* 494) in tropical forests. The jerboa burrows in sandy deserts. By converting (*Page* 526) the desert into a garden, draining marshes, cutting canals, turning the

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courses of rivers, clearing away forests in one place and planting them in others, man has altered the climate, and increased or diminished the quantity of rain. Man's influence on vegetation has been immense, and it is chiefly through his tendency to cut down forest trees that he has produced the greatest amount of change on the surface of the earth. In warm countries, districts which have no clothing of trees, the rainfall descends in sudden deluges, and the dry seasons are excessively prolonged. Thus the violent rain-wash prevents the accumulation of humus, and the surface of the earth is scorched to sterility by months of fierce sun.

Stow, Rev. F. W. *Symons's Meteorol. Mag.*, vol. v. (*rs.*)

(*Page* 180.) The air is generally saturated most of the day during a sea fog here, whatever Dr. Allnatt may say to the contrary. [No place is mentioned, but it is probably near Whitby.]

Strachan, R. *Symons's Meteorol. Mag.*, vol. v. (*rs.*)

(*Page* 73.) Lamont's evaporimeter consists of two bowls connected by a glass tube; one is covered, the other exposed to the air. The tube rests on a scale of 25 in.; it contains an air bubble, which moves along the scale as the water is evaporated from the open vessel.

Symons's Meteorol. Mag., vol. v. (*rs.*)

(*Page* 2.) Snell's aneroid hygrometer is made by a private gentleman at Saltash. It is made of a piece of whipcord, dipped in some solution (salt and water), fastened so as to act on an axle, and kept stretched by a lead weight. W. B. Kesteven tested it. He reports that it is extremely sensitive to the slightest change of atmospheric dryness or moisture, its rise or fall often anticipating change of the barometer and of the wet and dry bulb hygrometer. It is so far uniform in its (*Page* 3) susceptibility that an accurate scale would give indications of humidity in the same way as the dry and wet bulb thermometer. It might be rendered more (*Page* 74) exact than it is. H. C. Russell's table gives the humidity by simple inspection by means of curves. His values agree closely with Glaisher's hygro- (*Page* 75) metrical tables, 4th ed.; but not with the first edition nor with Guyot. It does not give a lower humidity than 40.

(*Page* 93.) The country [England] is suffering from lack of rain for months, yet the moisture has always been close at hand. The upper regions of the air have been abundantly supplied with water. The moist south-westers have blown over the land. The skies have even been for the most part cloud-laden, yet the winds have drifted onward those vehicles of the precious moisture. The moisture-laden air current which comes from over the Atlantic may flow so low that the western hills rob it of its wealth of water, and suffer dry air alone to pass over the rest of the country; or, on the other hand, the south-westers may range so high as to carry the moisture-laden clouds past our isles; or the south-westers may be beaten back through all the summer months by the dry winds from the east, and so a real dryness of the air prevail, as during the exceptional weather of May 1866. Yet it is comparatively seldom that we owe our droughts to such a real dryness of the upper regions of the atmosphere. This is proved by the fact that our summer nights are seldom cold. Tyndall notices, that a day's steady rainfall in a region no larger than Middlesex corresponds to the action of a force capable of raising more than 30,000 million of tons to the height of a mile. All the coal which men could dig from the earth in many centuries would not give out enough heat to produce, by the evaporation of (*Page* 94) water, the earth's rain supply for a single year. But there are few subjects on which meteorology throws less light than on the causes which influence the dryness or wetness of our summers. At times it would almost seem as though the weather of tropical or sub-tropical regions were brought to us with the northing of the sun. But during other summers an irregular variation prevails. The

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attempts to discover any traces of periodicity in the recurrence of dry and moist summers have not hitherto been rewarded with success. Nor does there seem to be any evidence that our climate is gradually changing as regards humidity.

[No. for September.]

(*Page* 130.) The observer at Cirencester says the extreme dryness of the weather from January to May has been due to the tendency of the wind to cling to the north.

[No. for October.]

(*Page* 135.) The Report of the Kew Committee states that the staff at Kew continue to make occasional absolute hygrometrical observations, by means of Regnault's instrument, with the view of testing the accuracy of the method of deducing the dew-point from the observations with the dry and wet bulb thermometer.

[No. for November.]

(*Page* 169.) The Rev. R. B. Belcher, in a paper read to the British Association, stated that the explosion on the Mersey of the *Lotty Sleigh* was heard where he lived, a hundred miles off. It was followed by an immense black cloud and heavy rain.

1871.

Chandless, Wm. *Journ. Roy. Geog. Soc.*, vol. xl. (1871) (*rs*).

(*Page* 432.) The following were the results of ten months' observations at Manaos, scattered over several years. The maximum and minimum were those obtained at the regular hours of observation.

	VAPOUR TENSION.	HUMIDITY.
3 A.M.	·796 inches.	92
9 A.M.	·830 ,,	81
3 P.M.	·811 ,,	70
9 P.M.	·833 ,,	88
Mean	·818 ,,	83
Max.	·980 ,,	98
Min.	·602 ,,	42

Dines, George. *Evaporation. Symons's Meteorol. Mag.*, vol. vi., pp. 190—192 (*rsp*).

(*Page* 191.) I should prefer Dr. Hudson's Proposition I. to be expressed thus: When air is saturated with moisture, and the water is of the same temperature as the air, neither evaporation nor condensation can take place. I do not like the words "when air is saturated," as they tend to convey a false impression; except as it regards the dew-point, it is a matter of little consequence whether the air is saturated or not. Other circumstances being the same, it is the difference between the temperature of the water and that of the dew-point which determines the amount both of evaporation and of condensation. In paragraph 5, p. 167 (see Notes, 1871, Hudson), a case is supposed, which, in my opinion, cannot exist; air, under the circumstances named, is not capable of abstracting vapour, and, therefore, cannot surrender its previous spoils again; on the contrary, water of a lower temperature than the dew-point will rob the driest air of a part of the small quantity of moisture which it contains; this I have found to be the case by placing water of a lower temperature than the dew-point in the heated air of a drying-room, when I have invariably found it to increase in weight. It is true that in Table 2 of my paper evaporation appears to take place from water when at a lower temperature than the dew-point, but it will be observed that the words "calculated dew-point" are generally used, and the tendency of my experiments was to throw a doubt upon the correctness of the tables used for the determination of the dew-point; further

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experiments have convinced me that they generally, but not always, give the dew-point too high, but some anomalies which I have noticed lead me, at times, to doubt if the wet and dry bulbs can ever give more than an approximation to the moisture in the atmosphere. The time at which evaporation commences from water or from any other substance covered with moisture in its relation to the dew-point, can only be determined by the most delicate experiments. To me it has sometimes appeared to differ in different currents of air, but the whole question is beset with difficulties of no ordinary kind, one of which would be to determine the temperature, not of the water, but of its surface, and, at the same time, to get the correct dew-point; the latter at times appears very changeable. It seems that masses of air, very differently charged with moisture, are rolling over the surface of the earth in the same manner as the clouds above, the difference being that they are invisible. Nothing yet said (*Page* 192) shakes my conviction that condensation occurs if the surface temperature of water is below the dew-point, evaporation if it is above.

Everett, J. D. (*B.* 1871, 6.)

(*Page* 353.) The formulæ used for calculating the dew-point have been based on the specific gravity of air, as determined by Delaroche and Berard, or ·267; the correct value is that obtained by Regnault, or ·237. With this correction, the discrepancies found to exist between calculation and observation are increased, and amount, on an average, to about 25 per cent. of the difference between wet bulb temperature and the dew-point. August and Apjohn erred in assuming that the air round the wet bulb falls to the temperature of the bulb, and becomes saturated. These two assumptions would jointly produce no error in the result if the depression of temperature in the different portions of air were exactly proportional to their increments of vapour tension, and if some of the air were saturated at the temperature of the wet bulb. But it is probable that when there is little or no wind, the mass of air which falls sensibly in temperature is larger than that which receives a sensible accession of vapour, and that in high wind the supposition that some of the air has fallen to the temperature of the wet bulb is more nearly fulfilled than the supposition that it has taken up enough vapour to saturate it. The effect of radiation, which is ignored in the formulæ, leads in the same direction as these two inequalities, and all three are roughly compensated for by attributing to air a greater specific heat than it actually has.

Ferrell, William. (*B.* 1871, 8.)

(*Page* 226.) Buchan attributes the low barometer in the Polar regions to the effect of vapour in the atmosphere; but the amount of vapour in the equatorial regions is far greater than in the cold Polar regions.

Frere, Sir Bartle. *Journ. Roy. Geog. Soc.*, vol. xl. (1871) (*rs*).

(*Page* 203.) In the Thurr droughts occur for months, and sometimes for years. Still, grasses thrive and spring up with amazing rapidity after the fall of a few inches of rain. The soil is loose, and the roots of the plants are of prodigious (*Page* 204) lengths. No animal requiring much water can stand its protracted droughts. Thus tigers are never seen in the desert, although they abound wherever jungle is to be found in these regions: leopards and lions are rare. Three (*Page* 205) foxes and a jackal are known. Wolves are numerous. The wild hog is absent. Of deer and antelopes, the only one is the gazelle, which is said to subsist without any moisture except that afforded by dew and herbage. Jerboas are the most characteristic animals. Snakes are numerous. There are horned cattle, sheep, and camels.

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Hudson, Henry. *On Evaporation of Water. Symons's Meteorol. Mag.*, vol. vi., pp. 166-168 (*rsp*).

(*Page* 166.) The following propositions appear to embrace and explain the phenomena of evaporation observed by Mr. Dines :—

1. When air is saturated with moisture at temperature of atmosphere, neither evaporation nor condensation can take place. 2. When air is saturated, but the water of a higher temperature, evaporation must take place, for the air, which is warmed by contact with the water, being no longer saturated, is capable of receiving and carrying away additional moisture; hence the water must lose weight, and also be cooled by the abstraction of the latent heat of the vapour thus eliminated. 3. When air is saturated, but the water of a lower temperature, condensation must take place on the surface of the water, for the air, chilled by contact, can no longer retain the same amount of vapour, consequently the weight of the water will be increased, and its temperature also must rise from the influence (*Page* 167) of the warmer air. 4. Let us suppose both the air and water to be several degrees above the temperature of the wet bulb, the air in contact with the water will obviously carry off vapour from it. Hence the weight of the water will diminish, and its temperature must fall, as in the case of the wet bulb, until the latent heat of the vapour so abstracted is exactly compensated for by the heat, from all sources, which the water-vessel receives. After this occurs, evaporation will still go on, and consequently the water will lose weight, although the temperature of the water may remain stationary. 5. Let us suppose the water to be several degrees below the dew-point temperature, while the air is several degrees above it; the air now in contact with the water is capable of abstracting vapour until it reaches its temperature of saturation. But, being chilled further by the contact with the water, it is compelled, as I may say, to surrender its previous spoils again, so that when the water is a certain number of degrees below the dew-point, the weight of moisture which the air could vaporize, in falling to the temperature of the wet bulb, will be exactly balanced by the quantity of vapour which the colder water would abstract from the air after it had attained the condition of saturation; so soon, however, as the temperature of the water rises above this point, although still, perhaps, some degrees below the dew-point, the evaporative influence will prevail, contrary to the first proposition laid down by Mr. Dines, that no evaporation takes place from water unless the temperature of the water is greater than that of the dew-point. At the close of the second table (p. 201) he gives an experiment totally opposed to such a conclusion. In the last line of his table, his dry bulb is at 59° and the wet bulb at 53·8°; his calculated dew-point being 49·2°, and temperature of water 38·6°. After about a quarter of an hour, condensation ceased, temperature of water being 44°, and two minutes afterwards evaporation commenced, with water at 45°. He has not stated the temperatures of the wet and dry thermometers at these precise points, but I cannot believe that the dew-point had fallen, in the time specified, below 45°; in fact, in the previous quarter of an hour the temperature of the dry bulb had risen from 58·1° to 59°, and of the wet bulb from 53·1° to 53·8° (his calculated dew-point having also risen). Now, assuming the temperatures of dry and wet bulb to remain at 59° and 53·8° respectively, my views lead to the following results :—I find the weight of water which 1000 cubic inches of dry air could vaporize in falling from 59° to 53·8° to be 0·35836 grains, and the maximum weight of 1000 cubic inches of vapour at 53·8° is 2·70631 grains. Hence, deducting the former from the latter, we have 2·34795 grains, which is the maximum weight of 1000 cubic inches of vapour at 49·69°, and this, by my calculation, is the dew-point, instead of 49·2°. Now, if we again deduct (*Page* 168) 0·35836 from 2·34795 grains (in order to find out at what temperature

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below the dew-point the condensation of vapour is equal to the previous evaporation during the fall from 59° to 53·8°) we get 1·9859 grains, which is the maximum weight of vapour in 1000 cubic inches at 45°. Hence, according to my views, this is the temperature at which evaporation ought to begin to preponderate over the tendency to evaporation, and it is evident this agrees perfectly with what Mr. Dines has recorded as the result of his experiment. After this, in about eleven minutes, he states the temperature of the water to have risen to 49·8° and that 0·4 grains of water had been vaporized in the interval, so that after this amount of evaporation the water was probably very little, if at all, above the dew-point temperature.

Malet, H P. *Symons's Meteorol. Mag.*, vol. vi. (*rep.*)

(*Page* 204.) In West India, at an elevation of 4,000 ft., I have frequently seen showers falling below me. I have walked into the clouds, and met first mist (*Page* 206), then drizzle, then rain. From numerous facts observed by me, I gathered that rain clouds vary in thickness from about a hundred yards to more than a mile, that the weight or size of the raindrops increases as they reach the point of attraction. This point is the earth, and may be a mountain top or a level plain; as the latter does not fall in with so much moisture as the hills, it gets less rain. Some seem to think that a cloud discharges its contents in actual raindrops; if it did, there would be no moisture to go on with. But it is otherwise, and while some of the vapour is accumulating into raindrops, the rest is passing on. In India there are seldom two layers or more of clouds; in England, as far as I have been able to ascertain, it never rains without two layers.

Monck, W H. S. (*B* 1871, 17.)

(*Page* 495.) Aqueous vapour is not so important an agent as is usually supposed. The specific heat of aqueous vapour at constant volume is ·313, and that at constant pressure is ·475, showing a ratio between the heat units expended on internal and external work of 1 to 0·517. In dry air the proportion is 1 to 0·421. In the one case, in round numbers, 30 per cent. is employed in producing expansion; and in the other 35 per cent. For equal quantities, the heat absorbed by vapour has little, if any, greater effect in producing air currents or barometric depressions than that absorbed by air.

Poey, A. (*B.* 1871, 18.)

[The new cloud is Dr. Clouston's pocky cloud. He noticed it in connection with the same meteorological conditions as are described by A. Buchan in 1868.]

Stewart, Balfour. (*B.* 1871, 20.)

(*Page* 63.) Charts of relative humidity are without value, and do not present the continuity shown in charts of vapour tension. Watery vapour is one of the most important elements in studying the movement of air. Charts representing the distribution of vapour of water would be of the greatest utility. The element of relative humidity is of little use in meteorological researches. Besides these two (*Page* 64) elements, there is what may be called the hygrometric quality, which is important. It means the weight of aqueous vapour per hundred parts by weight of air. As long as the pressure remains the same it will be represented by the vapour tension, and since the variations of pressure at the surface of the earth differ little, the hygrometric quality will be there approximately represented by the vapour tension. But under small pressure the vapour tension will not represent the hygrometric quality, which will then be indicated by the ratio between the pressure of aqueous vapour and that of air.

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Stow, Rev. F. W. *Symons's Meteorol. Mag.*, vol. vi. (*rsp.*) (No. for June.)

(*Page* 70.) Does the old-fashioned hypothesis suggested for the decrease of rainfall with height account for the facts, especially the greater decrease in winter than in summer? Does it not assume what can be disproved—viz., that the temperature of falling rain is almost always below the dew-point of the air near the ground? And if it were true that the raindrops gain more than they lose till they reach the ground, would not the beginning of rain dry the air near the ground by depriving it of moisture, and even warm it by the latent heat given out in condensation? I am much more disposed to believe that, on the contrary, the drops lose volume by imparting moisture to the air, for it is a matter of common observation that when it begins to rain the air becomes damp and generally cold.

Symons's Meteorol. Mag., vol. vi. (*rsp.*)

(*Page* 144.) We give a *resumé* of Mr. Dines's observations on evaporation. A delicate balance was arranged with a vessel of water in one pan and weights in the other. It was found that evaporation from the hot water continued until its temperature fell below the dew-point temperature, as computed by Mr. Glaisher's tables, and that in cold water condensation ceased some 3° or 4° below the computed dew-point temperature. These results indicate one of three things: 1. That there is some error in the experiments. 2. That there is some error in the hygrometrical tables. 3. That the dry and wet bulb thermometers do not enable us to ascertain the dew-point correctly. The second phase of the investigation is given in the *Proc. Meteorol. Soc. for March*, 1871. Thus during some experiments it was found that when the difference of the dry and wet bulb thermometers amounted to 8° or 9° evaporation commenced from a surface of water at a time when the thermometer immersed in the water showed a temperature of from 3° to 4° below (*Page* 146) the temperature of the dew-point as obtained by calculation, but on repeating the experiment in air saturated with moisture, when the dew-point temperature could be obtained direct from the thermometer, the dew-point temperature and that of the water, when evaporation commenced, agreed with each other. As no satisfactory reasons have been assigned for this discrepancy, I made other experiments, as follows; small globes and cylinders, both of glass and metal, were used, the substance of which was made as thin as possible; these were filled with iced water; a thermometer, with a bulb 1½ inches in length, was inserted in the water, the stem of the thermometer passing through the centre of the stopper; the whole was then suspended from the beam of a delicate balance. The outsides of the vessels were, of course, immediately covered with condensation, the amount of which was only occasionally noted, the one object of the experiments being to determine the exact temperatures of the water at the time when condensation ceased upon the surface of the vessels, and the moisture deposited upon them commenced to evaporate; that time was clearly shown by the stationary position of the index rod attached to the balance, just previously to its commencing a retrograde movement. If the thermometer immersed in the water at the time this change took place fairly represented the temperature of the outside of the vessel, it would, without doubt, give also at the same time the true dew-point temperature. Every care was taken with the covering and supply of moisture to the wet bulb thermometers, and, as an additional precaution, two sets of dry and wet bulbs were used, the difference (8° to 9°) of which did not vary much from each other; but those which gave the widest readings, and, consequently, the lowest dew-points, were taken. Whether the vessels used were larger or smaller, of glass or of metal, or whether the moisture upon the outside was allowed to accumulate almost in drops, or the film of moisture so thin as to be scarcely weighable, the results were nearly

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the same; condensation ceased, and evaporation commenced from the surface of the vessels at a time when the water inside the vessels was from 3° to 4° below the dew-point temperature, as obtained by calculation. It may be said the thermometer in the water does not give the temperature of the surface from which evaporation takes place; the objection has force; but it also applies to both Daniell's and Regnault's hygrometers as at present used. True, there are other differences in the mode of operation; in them it is a sinking temperature; in mine a rising one. In them the point of condensation is determined by the eye; in my experiments by a balance; but these differences do not seem to account for the different results. As the indications of the wet and dry bulb hygrometer had been found to accord with those given by Daniell's and Regnault's, I conclude that the factors given in Table I. of Glaisher's hygrometrical tables are incorrect. Now we come to the third phase of the inquiry—viz., a consideration of Dines's sensitive hygrometer, made by (*Page* 147) Casella. In it a stream of cold water passes through the vessel; at one end is a very thin black glass plate, beneath which is the bulb of a thermometer. The temperature of the upper and lower surfaces of the glass is nearly the same; and the slab does not differ from the thermometer bulb more than 2° or 3°. The glass is cooled by the water; as soon as dew appears on it the water flow is stopped, and the temperature is taken from the thermometers. This is the dew-point. By using a piece of wash leather to dry the glass successive deposits of dew may be rapidly obtained, when the dew-point will be found sometimes to vary considerably in a short time, the dew upon the glass appearing and disappearing several times in a minute. The instrument has extreme sensibility, and is perfectly under the control of the observer, and its price is very moderate.

1872.

Anderson, J. F. (*B.* 1872, 1.)

(*Page* 221.) He was able (at Pau) to see the small bodies alluded to by Waldner with the naked eye, or with a small telescope, by looking at the sky close to the sun's disc just within a shadow. On June 9th and 10th the haziness round the sun was produced by the reflection of the sunbeams from innumerable little particles. What were these particles? They certainly look like miniature snow storms.

Brumham, G. D. *Symons's Meteorol. Mag.*, vol. vii. (*rsp.*)

[No. for November.]

(*Page* 172.) Excessive moisture retards wheat. Hence the ripening of wheat depends (*Page* 173) on dryness of air as well as temperature. The early maturing of wheat indicates the previous prevalence of dry weather as much as, or more, than it does that of shade heat.

C., W. H. H. *Chemical Hygrometer. Symons's Meteorol. Mag.*, vol. vii. (*rsp.*)

(*Page* 155.) Air is drawn through U-shaped tubes containing chloride of calcium or strong sulphuric acid, by means of two turnover aspirators, each containing a gallon of air. The increase of weight in the chloride of calcium tube indicates the amount of moisture in so many gallons of air.

Davis, Henry. *Prestel's Hygrometer. Symons's Meteorol. Mag.*, vol. vii., p. 204 (*rsp*).

(*Page* 204.) There are objections to Prestel's hygrometer. Birds can drink from the open vessel; the wind would blow the water over the side in gales; and the atmospheric pressure would keep the water permanently in the gauge.

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Haviland, Alfred. *Symons's Meteorol. Mag.*, vol. vii. (*rsp.*)

[No. for July.]

(*Page* 116.) In the western sky at Hampstead, on June 23rd, 1872, there were some persistent cirri, forming strange groups, which lasted for more than an hour. The cirri bristled (electrically?).

Hudson, Henry. *Dew-point and other Hygrometers. Symons's Meteorol. Mag.*, vol. vii., pp. 19-20 (*rsp*).

(*Page* 19.) A limit to evaporation does not exist when the temperature of the air is higher than that of the liquid. I consider the dew-point in the case mentioned to be 49·69°, and that the air will take up vapour several degrees below, owing to (*Page* 20) its surplus heat. The amount of evaporation depends on so many circumstances, that in order to discover laws it will be necessary to separately investigate each circumstance.

Ingram, Hugh. *Symons's Meteorol. Mag.*, vol. vii. (*rsp.*)

(*Page* 229.) He calls mists vesicles of aqueous vapour (cloud proper). A raindrop, in displacing air as it falls, creates a vortex immediately behind it so as to suck in and attach to itself the particles of vapour nearest its path. Hence its increased size.

L., J. K. (*B.* 1872, 10.)

(*Page* 442.) Commander Maclear has noticed differences in the spectrum of different areas, and believes the changes in the atmospheric humidity distinctly correspond to the changes in the solar spectrum; an increasing humidity manifests itself by a shortening of the blue, and by a well-marked development of aqueous bands in the red and yellow.

Miller, S. H. *Evaporation. Symons's Meteorol. Mag.*, vol. vii., pp. 111, 129 (*rsp*).

(*Page* 129.) What methods for measuring evaporation did Vivian, Lamont, and Prestel suggest?

Rieder. (*B.* 1872, 17.)

(*Page* 39.) At Engelberg, November 14th, 1868, 5 to 6 A.M., repeated flashes of lightning. Shortly before five a swiftly passing flash was observed, while the sky was completely overcast.

Spottiswoode, William. (*B.* 1872, 23.)

(*Page* 334.) The diffusion of light in the air depends upon the presence of aqueous particles. That scattered by coarse particles is white, that by fine blue.

Stow, Rev. F. W. *Symons's Meteorol. Mag.*, vol. vii. (*rsp.*)

[No. for December.]

(*Page* 197.) In moist weather there is little sun, in dry there is much. Perhaps the influence of such weather on wheat is due to variation of sunshine, not of moisture. In the inland districts of Yorkshire the temperature rises faster in the morning than on the coast, owing to the comparative absence of mists, etc.

Waldner, H. (*B.* 1872, 25.)

(*Page* 304.) On looking through his large telescope at Weinheim, he caught sight of a number of luminous little bodies passing rapidly towards the east, which the focal distance of his lens showed were at from 200 to 4,000 metres only from the earth; the most numerous swarm occurred at about 500 metres. Their diameter varied from 10 to 52 mm., the average being 32 mm. The shape varied; the greater number were oblong, angular, resembling flakes; some few were orbicular, while some were

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stellate. On certain days, especially in April and May, they passed by without interruption for hours. Their number was connected with the purity of the sky. The daily minimum occurred in the morning and evening, and the maximum at noon. The annual minima were in summer and winter, and the maxima chiefly from April 20th to May 15th, and a lower one in August and September. Their number often increased after clouds had passed. Their velocity was irregular in the lower strata, being about two metres in a second, but became more regular in the higher strata, where, at 3,000 metres, I found them to pass eight metres during the same period, a rapidity agreeing closely with the cirri, which often passed at or above (*Page* 305) this distance. They all glittered in sunlight. In the lower strata they changed their direction every moment, or fell, but slower than gravitation requires. Their direction of movement corresponded nearly always with the wind and cloud movements. These bodies are evidently snowflakes and ice crystals. The minimum during winter may be owing in part to the deficiency of light.

Whipple, J. M. *Chemical Hygrometer. Symons's Meteorol. Mag.*, vol. vii., pp. 199-200 (*rsp*).

(*Page* 199.) The chemical hygrometer, described by W. H. H. C. is not of much use to the meteorologist, as it requires much patience and manipulative skill. It is a very laborious method of observing, and, after all, it only gives a mean (*Page* 200) for the time during which the observation is made. I think eventually we shall have to resort to some such form as Whitehouse's.

Nature. (*B.* 1872, 28.)

(*Page* 118.) There is much misconception as to the mode in which forests increase the amount of moisture in the air. They do so chiefly by pumping up the superfluous moisture from the soil and exhaling it from the leaves. Pettenkofer (Sitz. Akad. München, 1870. Bd. I., Heft 1) found that in an oak tree evaporation increased from May to July and then decreased till October. The total amount of its evaporation in the air was 539·16 centimetres of water. The average rainfall of the same area would be 65 centimetres, so that this evaporation is 8½ times more than that of its rainfall. This excess is drawn up from a great depth, so that the trees restore to the air what would otherwise go to the sea.

Symons's Meteorol. Mag., vol. vi. (*rsp.*)

(*Page* 213.) Describes Daniell's hygrometer. It was described by Daniell in 1820 (*Page* 214), and at the time was by far the best measurer of atmospheric moisture. Its accuracy has subsequently been overrated. Owing to the necessarily small size of the enclosed thermometer it is impossible to read accurately small fractions of a degree; and it is open to question if the thermometer indicates the actual temperature of the outer glass surface.

Vol. vii. (*rsp.*)

[No. for May.]

(*Page* 63.) Sawyer, in his 'Climate of Brighton,' has some weather proverbs, such as—

'When Wolsonbury has a cap
Hurstpierpoint will have a drap.'

This is a south country modification of a common prognostic, such as the following, some of which are taken from Inwards' 'Weather Lore.'

'If Riving Pike do wear a hood,
Be sure the day will ne'er be good.'

'When Cheviot ye see put on his cap,
Of rain ye'll have a wee bit drap.'

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'If Roesberry Topping wear a cap,
Let Cleveland then beware a clap.'

'When Breddon Hill puts on his hat,
Ye men of the vale beware of that.'

'When Largo Law puts on his hat,
Let Kellie Law beware of that;
When Kellie Law gets on his cap,
Largo Law may laugh at that.'

Largo Law is to the S.W. of Kellie Law.

[No. for June.]

(*Page* 73.) Dr. Ballot enforces the desirability of more frequent observations of the height of clouds.

[No. for August.]

(*Page* 129.) The following description of Prestel's apparatus is from *Procs. Meteorol. Soc.*, vol. iii., pp. 338-339. It comprises an open vessel of water. (*Page* 130) Connected with it is a measuring tube with a scale. The tube is filled with water and placed inverted in the vessel. As the water from the large vessel evaporates it is supplied from the tube. The open end of the tube has a brass ring mounting with a semicircular hole in the side through which the tube communicates with the vessel.

[No. for October.]

(*Page* 161.) M. Lemoine, in a paper read to the British Association, refers to Mr. Chapman's observations in South Africa. The desiccation of the country has been going on since the draining off of the waters owing to evaporation. The destruction of herbage and grass by fire, the use of the axe by native and colonist, and the formation of sheep walks, had facilitated the process of evaporation. As an illustration of the effects of evaporation producing desiccation, he quoted an experiment made by William Blore, at Wynberg Hill, about eight miles from Cape Town. He sank two cylindrical jars of the same size to the depth of 4 in., leaving them projecting an inch above the surface, and covering each with gauze to prevent ingress of sand, etc., and flies. The one was sunk where it was partially protected, but not covered by bush; the other was sunk in a newly-cleared plot of ground measuring about 60 ft. in diameter, surrounded by sugar bushes (*Protea mellifera, Thunb.*), of a considerable height, and otherwise protected from the prevailing wind by a belt of pine trees, about 120 ft. distant. Into each of these jars was put 20 ozs. of water on January 31st, at 10 A.M. On February 5th, at 5 P.M., the water remaining in each was carefully measured. The evaporation from the jar sunk in the cleared ground had been more than double the evaporation from that which was partially protected, though not covered, by the bush; the former being 1·854 in.; the latter ·863 in. The same results were obtained on repeating the experiment. Mr. Blore remarked that had the experiment been made in a more arid district the evaporation would have been greater; and that had it been made in the open country the difference would have been more marked. But taking the results obtained, the conclusions he arrived at were as follows:—The excess of evaporation from the more exposed above that from the more shaded jar was 1 in., or more accurately, ·991. An inch in six days will give for 102 days (the ordinary duration of the hot windy and dry season in the district) 17 in. This is equal to about 384,000 gallons per acre, and supposing 1,000 acres to be burned, blackened, and dried, what with sunlight, fire, heat, and wind, the evaporation would be an excess of 384,000 gallons of water above what would have been evaporated if the bush or grass had been unburned. Mr. Blore ascertained by experiment that on Wynberg Hill, while the deposit of dew upon a green surface amounted to 4·75, that on a white surface amounted only

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to 2, showing that the deposit of dew upon a green surface is more than double that upon a white; and he further ascertained that while the difference of temperature in the water in the two jars employed in the former experiment was only a few degrees the difference of temperature between black ground and ground shaded by bush was 25°, which would occasion a vastly greater difference in the amount of evaporation than that which occurred in his experiment. Humidity of air is of more importance than rainfall, and it is not necessary, in order to account for the phenomena observed, to suppose that forests attract clouds, neither is it necessary to suppose that they increase the rainfall otherwise than they do by the precipitation of the same moisture in the form of rain. The moisture of the humid atmosphere charged with carbonic acid and ammonia, attracted by the soil, does more to promote vegetation than would the same quantity of moisture falling in rain or applied by irrigation.

[No. for November.]

(*Page* 180.) George Dines described a new hygrometer. Objections had been made to the use of glass, owing to its non-conducting qualities, and in this form he used both glass and highly polished gilt metal. The metal was found to have no advantage over glass. [See Notes, 1823, Daniell, p. 142.]

1873.

Barns, J. W. *Journ. Roy. Geog. Soc.*, vol. xlii. (1873) (*rs*).

(*Page* 405.) The date palm characterizes arid climates with extreme summer heat and a low winter temperature.

Blakiston, T. *Journ. Roy. Geog. Soc.*, vol. xlii. (1873) (*rs*).

(*Page* 140.) At Hakodadi, fog is confined to the spring and summer months, but principally June.

Brine, Lindesay. *Journ. Roy. Geog. Soc.*, vol. xlii. (1873) (*rs*).

(*Page* 361.) In crossing the high lands of Guatemala, it is observable that the Indians dwelling among the mountains are much darker than those in the plains, and indeed it may be laid down as a general law that throughout Central America the colour of the native varies according to the height above the sea, and in a manner entirely opposed to what would naturally be expected. The skin of those who dwell in the highest and coldest regions is almost black, while below in the warm valleys and near the coast it is of a pale copper colour.

Grant, J. A. *Journ. Roy. Geog. Soc.*, vol. xlii. (1873) (*rs*).

(*Page* 259.) While delayed at Karagweh, I was much struck by the extreme blackness of skin in a race who came there from the Lake Victoria direction to sell coffee. The blackness of their skins reminded me forcibly of the races dwelling in the swampy regions of the Terais of India, and this to me at once marked their origin as a race living among swamps or lakes. They were Wahia, who live on the shore of Victoria Lake. Their spear is made of a white knotty wood, not of bamboo, for bamboo is not indigenous to swampy countries; it chooses rather to grow away from water.

Maury, T. B. (*B.* 1873, 7.)

(*Page* 125.) When once an area of low barometer is formed, it is the nucleus for a vast aggregation of meteoric forces. No matter how small at first, under favourable atmospheric conditions, the *courant ascendant* is formed, condensation aloft sets in, and the precipitation only seems to add fuel to the flame of the cyclonic engine. This process widens in geographical area, and after a few hours have elapsed, the storm may so develop as to cover a continent with its portentous canopy of cloud,

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while simultaneously strewing an ocean with wrecks, and throwing out in the open sky, more than a thousand miles in front, the fine filaments of the premonitory cirrus and cirronus. The depression in a cyclone is maintained so long only as the centre moves in a region sufficiently supplied with aqueous vapour to feed it. It is physically impossible for a storm to maintain its course or force over a dry and (*Page* 147) desiccated surface. The southerly winds of the north hemisphere come from the equatorial regions, and are highly charged with aqueous vapour. This vapour is absolutely essential to the sustenance of storms. The storm vortex is on the side where the greatest quantity of vapour is found. While yet in the band of easterly trade winds, the storm will invariably work its way to the most humid regions unless mechanically borne away by the great aerial current in which it is embedded. The cyclone tracks over all the oceans lie in the central bands of the great ocean currents of high temperature and great evaporation.

Mott, A. J. (*B.* 1873, 8.)

(*Page* 161.) The amount of evaporation must be the chief element in the question of rainfall; and the total evaporation must depend on the amount of wind; and thus be increased in proportion to the speed of the wind and by the increased surface caused in storms when waves and foam are created. The evaporation during a cyclone must be enormous. Wind is almost always drying even when rain is falling. The solar spots probably cause inequalities of temperature, which by the formation of barometric differences will give rise to special areas of evaporation.

Stevenson, T. (*B.* 1873, 15.)

(*Page* 153.) Hygrometric gradients should be used, and there should be horizontal and vertical hygrometric sections of the air made by a series of instruments near together.

Nature. (*B.* 1873, 17.)

(*Page* 342.) The dry and wet bulb is not trustworthy at low temperatures, and in cases of extreme dryness. No hygrometer yet devised gives approximately exact results in all cases. The instruments for measuring the rate of evaporation are the least satisfactory of those used in meteorology. The data are important elements.

Symons's Meteorol. Mag., vol. viii., p. 36 (*rsp*).

[No. for April.]

(*Page* 36.) At the Leipzig Conference Question 7 was:—What apparatus should be employed for determining the hygrometric condition of the air? Are the wet and dry bulb thermometers sufficient? Can the hair hygrometer be employed, and under what restrictions?

The answers were as follows:—Sr. F. da Silveira: Psychrometer for continuous observations. The hair hygrometer can never be accurate when exposed to the atmosphere. Carl Fritsch: Psychrometer sufficient and preferable to hair hygrometer. Thinks observers are not sufficiently careful to see that the wet bulb is really wet. Carl Hoffmeyer: Knows of nothing better than dry and wet bulb. Dr. Mohn: Psychrometer is most convenient, but for low temperatures hair hygrometer must be used with it. Professor Ragona: Strongly recommends a psychrometer by Tecnomasio Italiano in Milan. Calls attention to observations by Belli and Cantoni, showing that the results of thermometers with spherical bulb, covered with linen and moistened by a wetted wick, are unreliable. Believes hair hygrometer to be trustworthy if originally set by a psychrometer; recommends it to be enclosed in wire gauze. Symons: Dry and wet bulb not perfect, but preferable to Saussure's hair hygrometer. Dr. Wolf: Psychrometers always wrong when frost and

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thaw alternate rapidly; hair hygrometer should, therefore, be used as a check. The Committee: Psychrometers faulty in cases of extreme dryness; the hair hygrometer is erroneous at the dew-point. Neumayer: Regnault's hygrometer with an aspirator should be used. Von Oettingen: Regnault's hygrometer sometimes fails at very low temperatures.

[No. for May.]

(*Page* 53.) Question 15 was:—What apparatus is to be recommended for the measurement of evaporation? What is the most suitable exposure for the evaporimeter?

Answers:—

(*Page* 54.) Sr. F. da Silveira: Should be exposed to rain, sun, etc. Carl Fritsch: A vessel similar to a rain gauge, but shallower, exposed to sun and rain, but guarded against undue heating. Capt. Hoffmeyer: Attention must be paid to the temperature of the vaporimeter. Professor Ragona: Recommends Tecnomasio Italiano's vaporimeter or his own self-recording one. Bordeaux Meeting: Piche's hygrometer gives the most favourable results. Prestel: Recommends his own vaporimeter. Ebermayer: Recommends Lamont's vaporimeter.

Question 16:—In what way should the proportion of cloud in the sky be estimated and indicated? Is it desirable to introduce a special and universal language for clouds?

Answers:—

Sr. F. la Silveira: Clear sky = 10; overcast = 0. The introduction of universal symbols very desirable. Carl Fritsch: During the prevalence of thin cirrus and the breaking up of ground fog, there is difficulty in determining the true amount of cloud. The introduction of general symbols desirable. Dr. Mohn: Blue sky = 0; overcast = 10. Symbols very convenient. Symons: Have symbols if possible. The Bordeaux Meeting: The adoption of tenths of clear or cloudy sky will involve the disadvantages of two figures for telegraphy, instead of one. Approve use of symbols. The Committee recommend 0 = clear sky; 10 = overcast; that symbols be used; and that a selection be made from those submitted to next Congress.

(*Page* 95.) Ragona notices that at Modena the minimum is below 20 nine months out of the twelve. The lowest observed was 7 on April 9th, 1867.

1874.

Burder, G. F. *Symons's Meteorol. Mag.*, vol. ix. (*rsp.*)

[No. for September.]

(*Page* 123.) According to my own observations the inverted cumulus or pocky cloud never occurs in a marked degree except in the neighbourhood of a thunderstorm.

Elias, Ney. *Journ. Roy. Geog. Soc.*, vol. xliii. (1874) (*rs*).

(*Page* 143.) From September 24th to November 2nd, on which last date he was near Uliassutai in Mongolia, the day almost invariably broke clear and still, and remained so until nearly noon, when a strong north-wester would spring up, and with a more or less clouded sky, continue to blow until about an hour after sunset when it would die out, and the clouds would roll away.

Kirkwood, J. P. *Symons's Meteorol. Mag.*, vol. viii. (*rsp.*)

(*Page* 196.) Give me titles of books relating to evaporation.

Markham, C. R. *Journ. Roy. Geog. Soc.*, vol. xliii. (1874) (*rs*).

(*Page* 95.) The great heat of the Polar regions and the excessive cold are due to the dryness of the air allowing of radiation from the sun and from the earth.

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Ryves, Rev. J. T. *Symons's Meteorol. Mag.*, vol. ix. (*rsp.*)

[No. for August.]

(*Page* 103.) At Buildwas, on July 19th, the dry bulb read, between 3 and 4 P.M., 87°, the wet bulb 26°, which indicates a relative humidity of about 24.

Stow, Rev. F. W. *Symons's Meteorol. Mag.*, vol. ix. (*rsp.*)

[No. for September.]

(*Page* 115.) The absorption of the direct solar rays by the vapour of the atmosphere is proved in several distinct ways. 1. It is found that the elastic force of vapour is less on the ten days in each month in which radiation is most powerful, than on an average of the whole month. This is proved by five years' daily observation at Strathfield Turgiss, 1869—74; two years at Hawsker, near Whitby (1869—71); and one year's observation in 1872 at Harpenden. 2. It was also found by the above observations that N. and N.W. winds, which contain little moisture, are very favourable to solar radiation; whereas S. and S.E. winds are usually accompanied by much less powerful sunshine. The N.E. winds of spring, which are excessively dry, are also accompanied by intensely powerful solar radiation. 3. By frequent observations during cloudless weather, with nearly constant vapour tension, curves are obtained, representing the daily variations in solar radiation, produced by the changes in the sun's altitude, and consequent alteration of the length of the path which the beams pursue through the atmosphere. From these the percentage of the heat rays, which would be absorbed by the atmosphere if the sun was vertical, can be approximately determined, assuming that the tension of vapour remained as it was on the day or days of observation. It is then possible to calculate the amount of radiation due to the altitude of the sun at noon in the middle of each month for a constant vapour tension, and to compare this with the amount actually observed in each month on cloudless days. In this way it is found, that when the tension of vapour falls below the amount on the day which furnishes the data for calculation, the radiation rises above the calculated amount, and *vice versâ*. In fact, the sun's rays are more intense in winter than in summer, when the difference of altitude at noon is allowed for, because the absolute amount of vapour in winter is so much less. About 10 or 12 per cent. is the minimum of absorption of the sun's heat rays, while the maximum equals or even exceeds 20 per cent. Solar radiation increases with elevation above sea-level. Between 470 and 1,800 feet the difference is 5 per cent. of the amount observed at the lower station when the sun's altitude was 20°, and above 3 per cent. when it was 26°.

Strahan, W. *Symons's Meteorol. Mag.*, vol. ix. (*rsp.*)

[No. for August.]

(*Page* 112.) The following are cases of extreme dryness observed in India :—

		DRY.	WET.	DIFFERENCE.
June 4th, 1869.	Gwalior . . .	110·3°	69·7°	46·6°
,, 19th, 1873.	Meean Meer . .	112·2°	70·2°	42·0°

Thomson, J. *Journ. Roy. Geog. Soc.*, vol. xliii. (1874) (*rs*).

(*Page* 104.) In South Formosa the wet season begins in May and ends about September [and hence the dry season would be from September to May. The lat. is about 23° N.].

Wilson, W. *Journ. Roy. Geog. Soc.*, vol. xliii. (1874) (*rs*).

(*Page* 211.) In Palestine the dews are so heavy that they penetrate the tent and wet everything in it. The rainy season commences at the end of October or beginning of November, and lasts till March [so that the dry season would be between March and October].

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Symons's Meteorol. Mag., vol. viii. (*rep.*)

(*Page* 196.) Many titles of books on evaporation are given in 'British Rainfall,' 1867 to 1872. [He gives nine others, which are entered in 'Bibliography.']

Symons's Meteorol. Mag., vol. ix. (*rep.*)

[No. for December.]

(*Page* 171.) Professor Ragona, in his 'Lettere Meteorologiche,' treats of the increase of humidity and the decrease of temperature which produce rain. He finds that when it rains at Modena the average humidity is 87·8. In England the mean value would be nearer 97·8.

1875.*

Abercromby, Hon. R.

(*Page* 274.) The heat and damp which accompany cyclones are phenomena which (*Page* 275) are never absent in any part of the world. The character and quality of this heat differ greatly from that due to radiation. Extreme damp, mugginess, and a peculiar feeling of oppression are the leading features. As to the source of this heat and damp, it is evident that since their position relatively to the cyclone centre is always the same, they must be due to some phenomenon of cyclonic motion, and their isolated position shows that they are not merely due to the setting in of a (*Page* 276) southerly wind. There is strong presumptive evidence that the heat and damp which accompany one portion of a cyclone are due to a compression of that portion. Behind the centre of a cyclone is an area, less defined than the heat area, but possessed of opposite qualities, viz., cold, dryness, and an exhilarating influence on man and animals. This is probably due to rarefaction.

Blanford, H. F.

(*Page* 189.) The effect of increased radiation [solar] must be to increase evaporation, and, therefore, the clouds.

Smyth, P.

(*Page* 232.) He refers to the very heavy rains of July 1875 in France and England notwithstanding the barometer was high and steady. When in London on July 14th to 16th, he saw the line D with the spectroscope dark and broad. When he left the weather cleared up, and at York, where it was fine, the line was sharp, but narrow. In Edinburgh, on July 17th, the line was again seen very broad during bright (*Page* 253) sunshine, and was followed a few hours after by a steady rain. On July 20th there was a sensible alteration of the abnormal spectrum band. On July 23rd it rained with a normal sky spectrum, but then the barometer was low, wind W., and the temperature had fallen.

Nature.

(*Page* 100.) Hon. R. Abercromby (Meteorol. Soc., June 19th, 1875) remarked that a light ascensional column would give rise simply to an overcast sky, and a (*Page* 244) stronger one to rain. Scott described Lowe's graphic hygrometer. On the relation of temperature and moisture in the lower strata of the atmosphere at daybreak, R. Rubenson, in *Kong. Vetensk. Akad. Forhandl.*, Stockholm, January 13th, 1875.

Nature.

(*Page* 79.) Meteorol. Soc., November 17th. On a self-regulating atmometer. H. Miller.

* For fuller references, titles, and bibliographical details, referring to 1875 and subsequent years, see the Bibliography near the end of this volume.

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(*Page* 399.) Inst. Civil Engineers, February 29th. On evaporation and percolation. C. Greaves.

1876.

Murphy, J. J.

(*Page* 6.) If we are drying up, it must arise either from diminished ocean surface, or less heat, both of which would decrease evaporation. There seems to be no evidence in support of either, so that the diminution of rainfall must be a local phenomenon.

Murray, D.

(*Page* 76.) Sir C. W. Thomson, at the British Association, states that the reason why the water is moving in a body from the South Sea is that there is a greater amount of evaporation in the North Atlantic and over the north hemisphere generally, than there is of precipitation; whereas it seems almost obvious that in the south hemisphere, in the huge band of low barometric pressure round the south pole the precipitation is in excess of evaporation. He suggests that certain points should be cleared up before this is admitted. Is there no compensating current from the north? Is it likely that the evaporation in the north hemisphere is greater than that in the south? Even supposing this is so, is it known that this vapour is carried into the Antarctic regions for pre- (*Page* 77) cipitation? The wind phenomena militate against the view that a large body of vapour is carried from the north to the south hemisphere.

Nature.

(*Page* 520.) Moisture is, next to temperature, the most important climatic characteristic of wind. The humidity of winds having the same direction varies according as it belongs to a cyclonic or anticyclonic area.

Nature.

(*Page* 161.) *Zeits. f. Meteorol.*, March 1st. On the relations of temperature and moisture in the lowest atmospheric strata during the formation of dew, by R. Rubenson, Dr. Hamberg concluded that in the lower strata temperature (*Page* 162) increases with height on frosty nights, and that the absolute moisture is less on the ground than a few feet above it. Dr. Rubenson obtained some results in the summer of 1871. Before the fall of dew the absolute moisture continues to increase, and is greatest on the ground, diminishing with the height. As soon as dew begins to fall, moisture decreases on the surface of the ground, and the decrease keeps pace with the decrease of temperature. The decrease of moisture extends upwards rather rapidly, and can be detected at 4 feet just after the first deposition of dew. On the ground, the decrease per hour amounts to a maximum of about ·73 mm.; while half a foot above it the decrease only reaches ·65 mm., which is less than what corresponds to the lowering of temperature. The higher the instrument the later does the decrease of moisture show itself, and the less the change per hour. It appears that owing to a fall of temperature on the ground the air immediately above it becomes saturated, dew falls, and temperature and moisture diminish. At a certain point, owing either to diffusion or a descending current, fresh vapour supplies the place of that condensed as dew, and part of the loss of each stratum is made up by the moister strata above; but not the whole, for the diminution continues in all the strata. Time being required for the propagation of the

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decrease upward, the lowest stratum loses more of its moisture than any of the strata above it.

Nature.

(*Page* 444.) (Acad. Sci., Paris, August 28th.) Fautrat, in testing the influence of pine forests on the humidity of the air, found that the annual difference in saturation was in favour of the air above the pines ten hundredths.

(*Page* 562.) (Bull, Acad. Roy., Belgique). Montigny says scintillation increases with increase of vapour tension. It increases with the arrival of moist weather at all seasons.

Nature.

(*Page* 527.) D. Whitney has an article entitled 'Are we drying up?' in the *American Naturalist* for September 1876. It refers to the evidence of the former existence of larger and more extensive lakes in areas which are now without them, and also of diminished lakes and rivers. The drying up may possibly be owing to changes in the obliquity of the ecliptic, or in the perihelion distance of the earth.

Symons's Meteorol. Mag., vol. xi. (*rsp.*)

[No. for December.]

(*Page* 154.) [A description is given of the hygrometers and evaporimeters exhibited at the Loan Collection at the South Kensington Museum. Only those details are given here which bear upon aqueous vapour as an element of climate, or which may elucidate the history of investigation.] An old hygrometer was shown, designed by John Coventry. It consists of a number of discs of paper strung on a wire, and attached to the short arm of a lever; the long arm travels over a scale. The paper was probably saturated with salt, and its weight varied with the humidity of the air. Klinkerfues's bifilar hygrometer shows the humidity and the dew-point by inspection. The reduction is effected by means of two discs, one outer and one inner. There is an old dew-point instrument which we believe belongs to the Royal Society. It is an ordinary thermometer with a black bulb. The bulb is surrounded by muslin, and cooled by means of ether. The dew-point temperature is read off when dew appears on the black glass. It is the oldest of its class, but has no name attached to (*Page* 156) it, and no record of its history is given. Dr. Geisler's form seems to have great merits. A large bulb terminating the thermometer has muslin over it, and is cooled by ether. This bulb is connected by a tube with the large bulb of the thermometer. In this latter bulb is a hermetically-closed vessel containing ether. The cooling of the terminal bulb causes the ether of the interior of the thermometer to evaporate. And the thermometer bulb is cooled until dew appears, when the temperature gives the dew-point temperature. The evaporation measurers are not reliable. Lamont's atmometer has the defect that the small quantity of water is liable to be unduly heated. Professor Osnaghi shows the steel-yard evaporimeter. A vessel is at one end 5 in. in diameter; it contains water. As evaporation proceeds an index traverses a scale. The water is liable to undue heating, owing to its small bulk. In Ebermayer's evaporation apparatus (*Page* 158) is a box filled with soil, kept constantly moist by means of a reservoir. The objections to it are that 5 inches of soil is not the same as so much soil *in situ*, as the latter can draw upon the soil beneath; and the whole apparatus is apt to become abnormally hot. Morgenstein's atmometer is based upon the principles of capillarity and of Mariotte's bottle. Sand is saturated with water by capillarity supplied from a burette closed from the air on its upper end. A

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tube runs from the sand into the burette, and supplies air to the latter as the water evaporates from the sand. When the burette is nearly filled with air it is apt to be affected by temperature. This defect is remedied by means of a globular vessel, which receives any water that may be forced out in this way. The evaporating vessel is embedded in some badly conducting material. Its area is one square decimetre (4½ in.). The instrument is sensitive to the fraction of a drop of water. It may give accurately the loss from a surface of saturated sand, but it is quite unsuited for exposure to sun and rain. Prestel's atmometer (*Page* 159) was the earliest in which the bird fountain principle in Mariotte's bottle was applied; Morgenstein's is a refined edition of it.

1877.

Bonavia, E.

(*Page* 101.) He refers to the collection and increase of clouds early in October 1877, at Lucknow, before 3 P.M., and their gradual complete dissolution by two hours after sunset, as an indication that the cloud region became decidedly warmer after sunset than it had been during the day.

Broun, J. A.

(*Page* 333.) It appears that the monsoons on the west coast of India have a central current of maximum vapour depth or of velocity, which he suggests may be shifted north from year to year, according to some law like that of sun spots.

[The principle is of general application to other areas.]

C., H.

(*Page* 43.) For years we [in Newfoundland] have marked an intimate connection between the colours of clouds and the weather. Thus we have the cold dark blue and grey and the reddish-yellow masses of clouds as indicative of cold and snow, and we have the light bright grey with bright edges as indicating or accompanying a hard frost; the inky cloud flying in shreds, as indicative of wind and rain; the mottled cloud of the same colour or thereabouts is the sure indication of rain; the sickly-looking green, the deep blue gloom, the muddy, angry-looking red, and other such tints, as forecasts of storm, snow, rain, etc.; and frequently before a north-easter we have the grey-bluish and whitish clouds setting from N.E.

Czerny, F.

(*Page* 239.) It is purely the winds which determine the condition of moisture of the (*Page* 240) atmosphere. If an equatorial current was to rise over a high mountain range, it may appear on the other side as a hot, withering wind, the *föhn* of Continental writers, in the thirsty regions. [See Notes, 1861, Eaton, p. 13.]

Hill, S. A.

(*Page* 506.) It may be said that the fact that the rainfall is greatest in maximum sun-spot years, argues increased evaporation during these years. The great majority of the rainfall stations examined are within or near the tropics, or in the maritime districts of temperate regions, and their more abundant rainfall in years of maximum sun-spots might be explained by the diminished carrying power of the winds at that epoch of the Solar cycle.

Ley, Rev. W. C.

Page 254.) Local depressions starting from the edges of the great areas of excessive evaporation seem to be governed in their course by the distribution of

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relative humidity, and to be determined towards those districts in which precipitation is most in excess of evaporation. Consequently their forward development is generally somewhat towards the poles. In the south hemisphere the middle latitudes are almost entirely occupied by surfaces in which evaporation is excessive. In the northern they are represented, to a large extent, by areas of relatively slight (*Page* 334) evaporation. The easterly winds felt on the south border of a small cyclone, if pursued for a very limited distance, are often found to have undergone a complete change in the aspect of the clouds which they carry and in their humidity.

Ley, Rev. W. C. *Symons's Meteorol. Mag.*, vol. xii. (*rep.*)

[No. for February.]

(*Page* 9.) *Picus viridis.* Its laughing cry is seldom heard during humid weather, or when the sky is much overcast. The greenfinch is especially noisy in sultry, overcast weather.

Nature.

(*Page* 210.) Contributions to hygrometry. The wet bulb thermometer. By W. Marriott, read to the Meteorol. Soc., December 20th, 1876. The observations were made to determine what a wet bulb should be. Ten thermometers were used as wet bulbs. With three bulbs the water receptacles were placed at different angles, but it was found that the readings were not affected by the position of the water receptacle. Others were used with different thicknesses of muslin and conducting threads; the thermometers with the thinnest muslins always gave the lowest readings. Three pairs of dry and wet bulbs were used, one with a closed water reservoir, 6 in. from the dry bulb; the other two having open reservoirs which were respectively 3 in. and 1 in. from the dry bulb. It was found that the dry bulbs of the two latter read lower than the former in fine, dry weather, but when the air was damp, and during rain, they generally read higher. The wet bulbs of the latter read a little higher than the former; this was mostly the case in damp weather.

Hon. R. Abercromby, Visibility, read to Meteorol. Soc., December 20th, 1876. Visibility is a very trustworthy prognostic of rain. The usual explanation that much moisture increases the transparency of the atmosphere is not borne out by (*Page* 541) observation. A correspondent in *Journ. Soc. Arts*, notices that in Ceylon, where the air is damp, the fruit of the coffee-plant has to be picked at maturity, else it would mould on the tree; whereas in Arabia, where the climate is dry, the fruit is allowed to ripen and drop off.

Nature.

(*Page* 197.) Steppes are characterized by absence of wood, the sandy surface is covered with grasses, dwarf herbs, and stunted bushes, which increase rapidly after the rainy season, but fade away altogether in the dry season. The steppe is defective in having no regular supply of water, being only here and there covered by streams, marshes, and lakes. The fauna of the steppe is characteristic, and is never met with in woody or marshy places. The most remarkable are the steppe rodents, such as jerboas, sousliks, and voles.

(*Page* 295.) (Hoffmeyer, in *Naturen*, June 1877.) Dr. Hann several years since explained the physical properties of the *föhn* wind. The air is forced over the mountains; in ascending it expands, and becomes cooled. On descending again it is compressed and heated. Its temperature rises more and more above the dew-point, and moisture will, with continually increasing ease, be held dissolved in the state of vapour. [See Notes, 1877, Czerny p. 240.]

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(*Page* 336.) (Acad. Sci., Paris, August 6th.) Comparative influence of leafy woods and resinous woods on rain and the hygrometric state of the air, by M. Fautrat. If vapours dissolved in the air were apparent like fogs we should find forests enveloped by a large moist screen, and for pine forests the envelope would be greater than for others. Pines retain in their branches more than half of the water poured on them, while leafy trees let 58 per cent. go to the ground.

(*Page* 369.) (Dr. Hamberg.) The absolute humidity of the air on clear nights in which no dew is deposited decreases from the ground upwards, just as happens during the day; but, on the other hand, with dew the humidity is least nearest the ground and increases with the height, and this influence of dew in diminishing the humidity extends upwards to at least 22 feet. Since his observations clearly show that the absolute humidity begins in the evening to diminish near the ground before any dew is observed to be deposited, and also diminishes at all heights on those nights during which no dew whatever is formed, Dr. Hamberg is of opinion that the diminution of the humidity is to be sought for in other physical causes than the deposition of dew.

(*Page* 392.) (Acad. Sci., Paris, August 20th.) Faye: The phenomena relative to the exceptional winter of 1876—7 are attributed by Hebert to a succession of strokes of sirocco which have communicated the heat and drought characteristic of them. The sirocco stroke, which caused the very mild dry weather in the beginning of the year, belonged to three great cyclones, which came, like all the others, from the Atlantic. [Perhaps this refers to Paris.]

Nature.

(*Page* 134.) (Hon. R. Abercromby. Meteorol. Soc., November 21st.) In a cyclone the broadest feature of the weather is an area of rain about the centre surrounded by a ring of cloud, beyond which the sky is clear. The position and precise forms of these areas vary with the type of pressure distribution, with the intensity of the cyclone, and with the rate of its progress; they are also influenced by local, diurnal, and seasonal variations. By recording the appearance (*Page* 135) to a single observer of any part of a cyclone as it passes over him, it is discovered that the area of rain and cloud ring may be divided into two portions,—the front and the rear,—differing in physical appearance and general character of the weather by a line drawn through the centre, in front of which the barometer is falling and in rear of which it is rising. In anti-cyclones synoptic charts show great irregularity in the positions of clouds, etc.

(*Page* 156.) (Fautrat. Acad. Sci. Paris, December 10th.) Above pines in the daytime there is always a rise of temperature from the solar heat being retained by the vapour enveloping the tree tops.

1878.

Abercromby, Hon. R.

(*Page* 143.) The process of averaging has resulted in the discovery of diurnal (*Page* 145) and annual variations of vapour and humidity. A watery sky is a sign of rain, because it is characteristic of the front or east part of a cyclone, and as a cyclone usually travels eastwards, an observer will successively be subjected to the influence of the cloudy and rainy parts of a cyclone before an area of fine weather again reaches him. Again, visibility with an overcast sky is a sign of rain, because the general condition of circulation in the atmosphere shown by straight isobars, during which it is observed, is never persistent for long, bu works up to a cyclone and rain. Visibility with a cloudless sky is a

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sign of rain when the cyclone is quickly followed by another. When that is not the case visibility is sometimes the precursor of persistent dry N.W. (*Page* 149) or N.E. winds. As to the 10 A.M. maximum of the barometer, if we look at the barographic trace for May 27th, 1877 [for London], we see that superimposed on the general rise of the barometer between 4 A.M. and 11 A.M. there is a very slight depression. The author's observations for the day are not very complete, but a similar depression is very common, and in many cases he has observed it to be associated with the temporary formation of heavy clouds about that time of day. If this is confirmed by future observation it would point to the conclusion that either overcasting of the sky or the formation of cloud interfere with those statical or dynamical changes which produce the 10 A.M. maximum. The author has pointed out in a former paper that there are critical periods of the formation or disappearance of cloud or fog superimposed on the general cyclone or anti-cyclone character of weather corresponding with the (*Page* 150) hours of diurnal barometer maxima and minima. Cloud produces a small diurnal range of temperature; at night it reduces the cold, and by day it reduces the sun's rays, so that a temporary clearing up of the sky might make the minimum temperature at almost any hour of the night, and the maximum (*Page* 151) at almost any hour of the day. If ever meteorology is to be a science, it is of the utmost importance to discriminate between the different kinds of clouds, and to determine their position in synoptic maps relative to cyclones and anti-cyclones.

Archibald, E. D.

(*Page* 505.) The hypothesis started by Hill and myself, that the solar radiation varies inversely with the sun spot frequency takes account of the probable effects of such a variation upon the vapour currents throughout the globe with respect to velocity, direction, season, and latitude. According as trades, anti-trades, monsoon or anti-monsoon, prevail (1) at different places at the same season; (2) at the same place at different seasons, so will specifically distinct effects arise both from the amount of vapour brought, and its conditions of precipitation, to determine which, not only the general conditions introduced by latitude and season, but the local and meteorological functions of the region must be carefully studied. The anti-trade, which in its seasonal shifts north and south traverses the entire temperate zone, should give signs of a secular change in intensity and humidity, corresponding according to the hypothesis, inversely with the sun's spots.

Broun, J. Allan.

(*Page* 126.) Herschel cites Humboldt's statements that the clearing away of clouds was well known to the seamen and pilots of Spanish America. Barnardin de St. Pierre, in his 'Voyage à l'Ile de Reunion,' says: 'I remarked constantly that the rising of the moon dissipated the clouds in a marked way. Two hours after rising the sky is perfectly clear' (April 1768). Faye says the moon has no such effect, supporting his conclusion by the Vigevano register by Serafini, who, however, records the condition of the sky between morning and evening only. M. Schiaparelli finds from this register that the sky was clearest in the first quarter of the moon. Faye's conclusion was faulty owing to the one-sided character of the evidence, and from his neglecting the observations of Mädler and Kreil, Park Harrison and Balfour Stewart. The moon's heat cannot be (*Page* 127) the cause of the phenomenon, as the moon gives no heat, so that it must be explained in some other way.

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King, Samuel. *Symons's Meteorol. Mag.*, vol. xiii. (*rep.*)

(*Page* 176.) He refers to dense fogs at Elswick Lodge. The ponds and ditches were covered with a greyish scum, which seems to indicate the fog was not entirely composed of watery particles. The wind had blown from the north for days.

Lockyer, J. N.

(*Page* 224.) I would ask whether during the night the molecules of aqueous vapour which absorb the blue have not been driven into higher forms, dew being one of them, owing to the reduction of temperature. This would explain the generic differences between sunrise and sunset colours, as also the golden instead of red sunsets which accompany the formation of cloud.

Murray, A. E. *Symons's Meteorol. Mag.*, vol. xiii. (*rep.*)

[No. for November. It is a newspaper insertion opp. p. 160.]

Col. 3. [There is no numbering in the original.] The clouding which occurs in the front of a barometric depression usually commences in the west, and the clouds at first often assume the appearance of streamers. [His statement is general, but he seems to have W. Europe in his mind.] An attempt was made to test if the moon influences the cloud, by means of observations made at Hastings. [It was assumed that if the thermometer on the ground was not very different from one 4 feet above ground that the sky was cloudy; if there was a great difference that the sky was clear]. For the year 1876 I picked out all the days of full moon, new moon, first and last quarters, and found that the difference between the thermometers was in the following proportions:—Full, 24·7; last quarter, 39·3; new, 41·0; first quarter, 46·6; showing that for that year there was most cloud at full moon, and least at the first quarter. I then combined one day on each side, and obtained the following figures:—Full, 91·9; last quarter, 108; first quarter, 116·3; new moon, 151·5; giving least at new moon, most at full. For 1877 the results were, for one day:—First quarter, 38·9; new, 43·1; full, 49·9; last quarter, 52·5; giving most to the first quarter, least to the last quarter. Including one day on each side, First quarter, 130·1; new moon, 137·5; last quarter, 150·1; full moon, 158·3; giving most to first quarter, least to the full. The two years are utterly at variance, and the impression I arrived at was that the different years would neutralize each other, and that the amount of cloud would prove to be on the average the same for all ages of the moon.

N., J. H.

(*Page* 672.) Boussingault ('Ann. de Chimie,' xii., p. 289) finds from the average of fourteen experiments that the hourly loss of water by evaporation of the leaves of a healthy Jerusalem artichoke for every square metre of foliage is 65 grammes in sunshine, 8 in shade, and 3 during the night. Mint gave off 82 grammes in sunshine and 36 in shade. A grape vine gave off 35 grammes in sunshine, 11 in shade, and 5 during the night. The whole plant had about 138 square metres of foliage, and in sunny weather would lose in 24 hours 48 kilogrammes of water. An acre of beets, it was calculated, could lose in 24 hours between (*Page* 673) 8,000 and 9,000 kilogrammes. Plants that have lost much of their constitutional water may absorb water from an atmosphere saturated with aqueous vapour.

Thomson, Sir C. W.

(*Page* 449.) There is a vast mass of cold ocean water which flows from the south far into the north hemisphere. The explanation of this is simple. For

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some cause, not fully understood, evaporation is greatly in excess of precipitation in the northern portion of the land hemisphere, while over the water hemisphere, and particularly its southern portion, the reverse is the case; thus one part of the general circulation of the ocean is carried on through the atmosphere, the water being raised in vapour in the northern hemisphere, hurried by the upper wind currents to the zone of low barometric pressure in the south, where it is precipitated in the form of snow or rain, and welling thence northward in the deepest channels on account of the high specific gravity dependent on its low temperature, it supplies the place of the water which has been removed.

Nature.

Page 385.) In Planté's experiments the electric current in presence of aqueous vapour yields a series of phenomena altogether analogous to the various phases of polar auroræ. If the positive electrode of the secondary pole of the secondary battery is brought into contact with the sides of a vessel of salt water, we observe, according to the distance of the film from the liquid, either a corona of luminous particles arranged round the electrode (fig. 8*), an arc bordered with a fringe of brilliant rays (fig. 9), or a sinuous line, which rapidly folds and refolds on itself (fig. 10). This undulatory movement in particular forms a complete analogy with what has been compared in auroræ to the undulations of the serpent, or to those of drapery agitated by the wind. [If so, then notes on auroræ would afford some information as to the distribution of aqueous vapour in the higher regions]. Planté explains the slow movement or stoppage (*Page* 386) of globular lightning by the movement or repose of the column of moist air strongly electrified and invisible, which serves as electrode. Almost (*Page* 436) every known portion of the south hemisphere (March 28th) has been suffering from a severe and protracted drought.

Nature.

(*Page* 288.) If the upper currents depicted by the Rev. W. C. Ley in his paper are to be regarded as tolerably close approximations to the movements of the cirrus-cloud of a cyclone, it follows that the region of the cirrus occupies a much higher level over the front portion of a cyclone than it does over its rear,—notably than over its north-west quadrant,—a point of prime importance in relation to the theory of storms. Professor Loomis supposes that in great storms the inflowing air escapes by an ascending current, carrying with it a large amount of vapour, which, as it is cooled, is condensed into cloud and rain, and that the heat thus liberated further expands the air.—Montigny (*Page* 292) shows that approaching moist weather increases the intensity of scin- (*Page* 352) tillation of stars (Acad. Sci. Paris, July 16th).—Crova observed that solar radiations were weakest with S. or S.W. winds, and strongest with N. or N.W. winds, the former increasing, the latter diminishing the vapour in the (*Page* 680) air. Dr. Hellmann (in the 30th report of the Royal Meteorological Institute of Prussia) finds that the daily maximum of cloud occurs at Crefeld about, or a little before, sunrise from September to April, whereas from May to August the maximum is from about 11 A.M. to 3 P.M. The monthly maximum which holds also for all hours of the day is December, while the month with clearest skies is September.

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Nature.

(*Page* 178.) Rev. W. Clement Ley: Cloud observation requires a special training of the eye. The classification and nomenclature is highly unsatisfactory, having been framed at a time when the relation of wind and weather to the distribution of barometric pressure was unknown; and with this relation the form and movements of the cloud are intimately connected. As regards configuration, clouds seem naturally divisible into two groups—those which arrange themselves in layers, whose vertical diameter is small as compared with its horizontal, and those which assume spherical or hemispherical shapes, and this division is related to certain physical conditions of the atmosphere, and of the earth's surface beneath the clouds. The movements of the upper clouds afford most valuable information concerning the distribution and movement of the areas of high and low barometric pressure. It may be sufficient to explain that in the front of an advancing barometric depression there usually extends a bank of the halo-producing cirro-stratus, the exterior edge of which is, roughly speaking, a parabola, the focus of which lies in the line about to be traversed by the centre of the depression. On the right hand of the centre this bank or sheet is abruptly broken, and is succeeded in the rear by local shower-clouds. On the left hand the sky commonly continues overcast, but the cloud-plane gradually descends until little is to be seen but low stratus. A backing of the upper current takes place until after the centre of the depression has passed. In whatever direction a depression is advancing the same characteristic phenomena are observed. Thus changes in the clouds indicate to us probable alterations of wind and weather. While the nimbus which exists in the front of a depression first makes its approach evident by changes in the higher cloud-strata, the process of nubefaction is the converse of this in those local showers which commonly occur on the right hand and in the rear of a centre of depression, and therefore when the barometer is rising, or just about to rise. These latter are developed in an upward direction through the formation of cumulus. The precipitation which occurs in them—always preceded by a change of appearance in the domes of clouds, which assume a soft and cirriform aspect—is attributed to the neutralization of electricities as the summit of the cloud passes into a higher region; but there are important differences between those cumuli which are likely, and those which are unlikely, to undergo this transformation. A physical explanation is given of the ordinary weather signs derived from the colours of the sky, from visibility, and from unusual refraction. Attention is invited to some unusual types of clouds, especially to a very elevated turreted stratus often erroneously termed cirro-cumulus, occurring with high temperature on the S.W. borders of anti-cyclones, a forerunner of thunderstorms. The formation of the low level stratus, and of the fog which usually prevails in our winter anti-cyclones, seems to be due to a downward movement of the air at a time when the earth's surface is colder than the atmosphere at a slight elevation above it.

Symons's Meteorol. Mag., vol. xiii. (*rsp.*)

[No. for May.]

(*Page* 55.) Alluard's hygrometer is essentially an improved Regnault's. By an arrangement of tubes ether is made to evaporate when wished, so as to cool a flat brass plate. The thermometer beneath the plate indicates the temperature at which dew is observed to form. This is made easier by having an annular surface near, which is not cooled. It is probably the best condensing hygrometer as yet introduced.

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[No. for July.]

(*Page* 91.) The questions proposed for discussion at the International Meteorological Congress include the following: Influence of cultivation, of grassing, and of replantation upon the production of dew, on the amount of rain-fall, and on its discharge from the surface of the earth. Origin and nature of dry fogs.

[No. for December.]

(*Page* 167.) In Blandford's theory of cyclones, an essential condition is that the cyclonic area be supplied with an indraught of a saturated current from the S.W. or W.S.W. [His remarks refer to North India, so that this would be also a warm quarter. His theory is in the main the same as Espy's.]

(*Page* 169.) Dr. Koppe's per cent. hygrometer is a Saussure's hygrometer with an arrangement for adjusting the index to the true reading.

1879.

Erskine, St. Vincent, *Journ. Roy. Geog. Soc.*, vol. xlviii. (1879). Read January 28th 1878. (*rs.*)

(*Page* 28.) At Muxango's Kraal [in South Mozambique] in 21° 2′ S. the mornings and evenings were calm and clear, and a sea breeze generally prevailed during the day laden with cumuli.

Hind, J. R.

(*Page* 189.) In B.C. 44 Plutarch and Dion Cassius record that for a whole year the sun was paler than usual, and gave less heat, the air continuing cold and misty.

Ley, Rev. W. C., in *Modern Meteorology*, 1879. (*rv.*)

(*Page* 102-103.) Very little progress has been made on the subject of clouds and (*Page* 103) weather signs. Aratus and Virgil were almost as advanced as some modern meteorologists. But this science is capable of great ultimate achievements. (*Page* 104.) Cloud observation is, in a very great measure, an incommunicable art. Keenness of sight, coupled with the habit of observing phenomena, are the first requisites; to this must be added a training of the eye by practise. By practise, I can now, when only the summit of a cloud forty miles away is visible above the distant horizon, state, with unfailing certainty, whether or not rain is falling from (*Page* 105) the under-surface of that cloud. Similarly, I can detect motions in cirri imperceptible to most observers. Inaccuracy in cloud observations, as regards distance or relative height, is the rule. For example, when cirrus or cirro-cumulus, at a great altitude, is moving in a rapid under-current, while thin clouds nearer to the earth's surface are stationary, or nearly so, most persons say the first-named (*Page* 106) cloud is the lower of the two strata. Forster made this mistake. Artists seldom paint clouds right, so that there is no way of referring to the (*Page* 107) objects by way of illustration except directly. Observers have not settled upon a reliable classification, and the nomenclature is faulty. Every classifi- (*Page* 108) cation must fail which does not take into account the intimate connection between the forms and movements of clouds with other elements. The behaviour of clouds is evidently controlled to a great extent by atmospheric electricity, but we know little about this. A thorough knowledge of all these is essential before we can make a good cloud classification. Clouds may be grouped in two divisions: (*Page* 109) first, those tending to arrange themselves in a horizontal layer, the components of which may be either fibrous and interlacing (which is commonly noticeable when the bed is at a great elevation), or more compactly welded (which is more common when the bed is near the earth's surface), but whose vertical diameter is in any case very small as compared with its horizontal; second, the clouds of

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massive spherical or hemispherical shapes, and having a plane base when in the inferior regions. Both exist at all altitudes at which clouds are visible. The first of these divisions comprises essentially the clouds of the night, and the second those (*Page* 110) of the day. Again, clouds of the first division are those of winter, those of the second, clouds of summer. But this rule applies with much fewer exceptions to the lower than it does to that of the higher portion of our hemisphere. Finally (but this rule has many exceptions), clouds of the first division are more common over the sea than over the land. On the west coast of Norway, for example, I have often seen the mainland covered with massive piles of cumulus, while over the sea were only a few streaks of linear cloud. Each little island had a little cumulus poised above it, a larger island a larger cumulus, and so on, the size of the cloud being almost exactly proportional to that of the land surface beneath it. It is even said that a reef when covered with shallow water often has its position marked by a solitary cloud of the cumulus form above it. I here adopt the term stratus for clouds of the first division, and cumulus for those of the second. The most valuable weather signs are derived, not from the former, but from the direction of motions (*Page* 111) of clouds of different levels. Movements of the highest clouds afford information of the highest value concerning the distribution and movements of the (*Page* 112) areas of barometric pressure existing at the time of observation. Here I apply the term 'cirrus' only to the 'curl clouds,' or 'mares' tails,' which float at a high elevation; cirro-stratus to the halo-producing sheet; cirro-cumulus to the (*Page* 113) small white nebulæ which float at the same level as the cirrus and cirro-stratus.

[He then points out how the movements of clouds indicate the positions of areas of high and low pressure; these details more pertinently appertain to barometric pressure and wind, but those which bear upon the distribution of aqueous vapour are given here.]

(*Page* 115.) There commonly exists in front of an advancing barometric depression a great bank of the frozen moisture in the high regions of the atmosphere which we call cirro-stratus. Synchronous observations show that the edge of this bank is commonly curved, and that the curve is, roughly speaking, a parabola, the focus of which lies nearly in the line along which the centre of the depression is about to travel. We do not, however, commonly see this curve in looking at the cloud. What we do see are longitudinal threads, or filaments of thin cloud, at an altitude (*Page* 116) of between 25,000 and 40,000 feet above the earth, and so arranged as to be parallel to each other. Outlying streaks of this cloud often form from twenty to one hundred miles in advance of the main pack, the pioneers of the coming army, and can be examined without difficulty. These threads of ice crystals terminate in most attenuated points which are often curled more or less outwards or upwards, being kept asunder by electric repulsion, the whole thread acting as a horizontal conductor of electricity. As the actual bank comes over us the threads which compose it are seen to be more or less reticulated, forming a filmy sheet or canopy, the structure of which becomes less and less discernible. This is the form of cloud which produces halos. Occasionally, indeed, even from the first appearance of the sheet, we can scarcely discern any structure in it at all; the sky seems simply to become gradually overspread with a milky-looking film of whitish cloud matter. In this latter case we infer that the upper regions are especially humid, and that the crystals being less insulated, consequently do not arrange themselves in definite threads. In any case, as the bank becomes more fully over our station its under surface becomes lower, and is at the same time rendered indistinct by the formation of visible cloud matter in the lower regions of the atmosphere. The commencement of this stage usually coincides with that of the fall in mercurial column, for the (*Page* 117) barometer is often either rising or stationary under the outlying threads

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already described. The rain-bringing wind now begins slowly to make itself felt at the earth's surface, the upper clouds cease to be visible at all, for the sky becomes totally covered by a composite mass of condensed vapour, and more or less precipitation at once sets in. I will now describe the movements of that upper current which has brought this canopy over our heads. I will suppose, then, first, that (*Page* 118) depressions are travelling from S.W. to N.E. (which is with us their most common direction), an anti-cyclone lying to the S.E. of our district. First, let us imagine ourselves to be situated actually upon the line which is to be traversed by the centre of the disturbance. Cirrus thread will first appear upon the south-west horizon, and parallel to that horizon. When some of them have arrived at the zenith we shall find them to travel from some point between W.S.W. and W.N.W. A little later, when an easterly wind has sprung up beneath, and when the cloud-bank is getting thick, we shall, if we can catch an opportunity of seeing the higher clouds, find that their current has backed; that is to say, is now from a rather more southerly point. By-and-by, when the barometer has reached, or nearly reached, its minimum, if we can see the clearing of the sky, we shall find that this upper current has backed so much as to be then moving from a south-easterly point. The cirri will then (*Page* 119) be ranged in lines from S.E. to N.W. Their appearance will, at the same time, have greatly altered; they will have become much more massive, and their threads or tufts will commonly be seen to point in a more or less downward direction, indicating that a cold and drier atmosphere is setting in below. Now let us imagine that the advancing depression is passing considerably to the N.W. side of our station. In this case the bank of cirro-stratus or its outlying threads have first been visible on the W. or W.N.W., and parallel to that horizon, and the upper current is found to travel from some N.W. point. As the bank spreads over us, while the south-westerly wind springs up beneath, we observe the upper cloud to be less thick and watery-looking than in the description given before. Cirro-cumulus in this case often takes the place of cirro-stratus, which is probably an indication that no great conduction is going on aloft. The rain, if any, falls in spasmodic showers, and when the sky clears it does so far more gradually than at more central stations. Here, too, we shall find that the upper current has backed, but only to a W. or S.W. point, so that when the wind at the earth's surface has veered to W., clouds of every level over our heads will be found to move from nearly the same quarter. (*Page* 120) Again, suppose a depression in going N.E. is leaving us upon its left. In this instance the cirro-stratus bank first shows itself on the S.S.W. horizon, and its motion is from some point between W.S.W. and S. In this case, after the sky has thickened, and a north-easterly wind has freshened with a falling glass, we very rarely get an opportunity of seeing the upper clouds at all; but when we do, at the time that the centre of the disturbance is nearest to us, we usually observe the upper current to have backed so as to come from S.E. The rain, in this instance, if it extends so far north as our station, is cold, thick, and continuous. As it ceases the clouds remain for a little while low and dreary, the clearing of the sky is very gradual, and when the wind is gone round to N. and the barometer is rising, we commonly see that the main vapour-plane has greatly descended, and that in lieu of the cirro-cumulus, and shower-clouds which are being experienced farther south, we have irregular but level stratus occupying the middle or rather lower beds of the atmosphere. Now, suppose we are in the rear of a disturbance, the central part of which has passed fairly off to the N.E. The sky is either clear or contains fragmentary cumulus and perhaps a few local shower-clouds. Such (*Page* 121) upper clouds as are seen are here commonly either masses or threads of somewhat curly cirrus; if threads, they stretch from N.W. to S.E., and their motion is, in any case, nearly from that direction, and this coincides, or nearly so, with the line of the isobars. It is a very rare thing to experience a N.W. wind (except

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immediately after it has veered to that point) which does not extend to the highest regions of the cloud-bearing atmosphere. When depressions are passing over or near us, the general distribution of high and low barometer is not always such as I have described. But the same rules apply, the winds being shifted. Thus if the depressions are going S.E., we must veer our words eight points or shift our diagram. I shall give one or two illustrations of what I mean. In weather in which we (*Page* 122) know from the previous changes of wind, and better still from our study of the daily maps, that the depressions or areas of rainy weather are travelling from S. to N., the appearance of a thick bank of cirro-stratus in the S.E., moving from some point between S.W. and S. after an interval of fine weather, is often an indication of coming rain, probably heavy, and accompanied by a muggy N.E. wind. On the other hand, if under the same circumstances the first threads of cirrus or cirro-stratus are observed in the W., but are found to travel from the S.W., the rainfall is not likely to reach our station, at least in more than one or two passing showers. Again, let the weather be such as we frequently have in spring, and occasionally in autumn and winter, winds backing and veering between W.S.W. and N., and the weather map showing us that areas of bad weather are travelling from the Scottish coasts towards Holland and Denmark. Let a fine day be succeeded by a watery bank of cirro-stratus in the N.W. travelling from N. or N.N.E., hard weather is to be expected; a blustering westerly wind accompanied by composite cloud-bank will probably veer to a cold N. or N.E. gale. On the other hand, under the same circumstances, let the cirrus appear first in the N.N.E., and travel from a northerly point, we are not then likely to experience more than a few slight showers of sleet or snow, with only a moderate (*Page* 123) backing or veering of the wind. The whole subject is one of great importance in making forecasts. Howard called every cloud from which rain falls a nimbus, but he appears to indicate a twofold division; but neither he nor his successors have told us much of this division. The symptoms of the extensive rainfall become first apparent, as a general rule, in the higher regions of our atmosphere; the cloud-bank begins at a high level, and is succeeded by a composite (*Page* 124) cloud at a lower level. The formation of passing showers is commonly the converse of this process. Almost every one must have observed the formation of a cumulus cloud, probably in the earlier hours of a showery day. Loose shreds of irregular cloudy matter begin to appear, here and there, under the bright blue. They are at first near the earth's surface, commonly in what has been the vapour plane of some stratus in the preceding night. Gradually, as rapid evaporation goes on under the increasing power of the sun's rays, the rising vapour forces upwards the particles above it, which are condensed by the cold of the higher regions into more and more mountainous masses. The under-surface remains level, reposing on the vapour-plane that is precisely at that altitude above the earth at which water passes from the gaseous state to that of mist. Below the cumulus the vapour is rising, but in the invisible state. The general shape of the cumulus is a hemisphere or cone with a surface formed of rounded protuberances. If you look at these you often see them continually tumbling back into the main body of the cloud, which yet continues to swell gradually upwards and outwards. That the older meteorologists were right in attributing this process principally to (*Page* 125) electric disturbance I cannot doubt. The cloud is now an insulated body, more or less highly charged. It repels the opposite electricity from the particles in its neighbourhood, and attracts them to itself, and an invisible rain of such particles is perpetually pouring probably upon all parts of its surface, the general charge of the cloud being retained partly by reason of its spherical surface. Similar clouds have been simultaneously forming in other parts of the heavens, and a thunder clap is heard on the distant horizon. We see in the quarter from which it has proceeded a cumulus or

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body of cumuli, the upper surface of which has put on quite a different appearance. It is spreading outwards and upwards in very thin cirrus-like filaments. It has, in fact, risen to such a height as to approach a stratum of gas intensely electrified, and with an electricity opposite to its own, and it is disposing the ice-prisms in innumerable threads, or feelers, spreading their attenuated points through the lofty regions of highly-rarefied air. We look again at the cumulus which we have watched before. Its glowing summit is undergoing a similar metamorphism, becoming softer and more downy than the lower portions of the cloud. Exactly at the same time that this change is taking place, we notice the atmosphere beneath our cloud to begin to be dimmed by the falling rain. The neutralisation of the electricities aloft has permitted the particles of water, hitherto kept asunder by repulsion, to unite and be discharged to the earth in rain. By-and-by little will be seen by the melting (*Page* 126) cloud save a certain amount of cirrus disposed above, and some loose flecks of scud or of soft cumulus beneath. This is the first formation of the typical shower. We have showers and showers; showers which have been formed a long way off, and showers, too, which are so embedded in other cloud forms, that we fail to get a glimpse of their cirriform summits, or even to distinguish the outlines of their sides or base. Showers of thick small rain even fall, in some circumstances, from low clouds of the stratus type, but these clouds also, just before their precipitation commences, lose their definiteness of outline as regards their upper surface, always looking as if they were discharging rain or snow in an upward as well as in a downward direction. But the formation that I have described is decidedly that most distinctive of the local shower in contrast to the widespread rain. Now we all know that the first steps of the formation which I have described are often discernible without being followed by any shower at all. In fine weather, especially in the spring and summer, we often see cumulus forming day after day, attaining its greatest dimensions about the hour of highest temperature, and either dissolving altogether about (*Page* 127) sunset or subsiding into the loose-spread stratus which is scattered at nightfall through the vapour-plane. The colours of the sky are, in many instances, related to the advance or retreat of the extensive nimbus. When cumulus begins to form under those other circumstances which lead us to suspect coming showers, watch its formation and appearance with great care. A very rapid upward development of the cloud while the outline is hard and the base very level is a bad sign, which is intensified if the protuberances of the upper surfaces are seen to toss and roll with much activity. When, as is very commonly the case, there are clouds of other species in the sky, notice these particularly. If there is a good deal of loose (*Page* 129) stratus, the remains of night cloud, around the base of the cumuli, and the latter are forcing their domes far above them, and gradually absorbing or repelling them beneath, the occurrence of showers before nightfall is probable. On the other hand, if there is stratus at a moderate altitude and cumuli are formed still lower down, and the summits of the latter seem inclined to spread out and blend with the stratus as they reach it, while the base of the cumuli become ill-defined and appear gradually melting, the weather is pretty sure to remain dry. In the latter case there is a sort of second cloud-plane in the middle region of the atmosphere, namely, that occupied by the stratus, which serves both to impede the evaporation from the earth's surface by checking the solar rays, and also to conduct horizontally the electricities of the cloud at a very early stage of their formation. The stratus is sometimes of a special kind, never or hardly ever seen before rain. The bold level (*Page* 130) based cumulus is often the precursor of a hail or thunderstorm. It is a very common thing on those occasions, when there is what I have called a second cloud plane at no very great altitude, to see cumulus when its summit reaches the plane, spreading out in very thick opaque folds. To the inexperienced eye these clouds have a somewhat stormy and formidable appearance, probably because they are

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rather similar in shape to those far loftier shower clouds whose summits have spread outwards into the cirrus regions of the atmosphere, and the untrained eye recognizes forms far more readily than distance. Yet clouds of this kind rarely or never produce a shower. They may be seen at all times of the year, but especially in spring, particularly in the eastern parts of an anti-cyclone. They are most commonly accompanied with a good deal of haze, and associated with a dry and harsh atmosphere. Luke Howard seems to have intended his term cumulo-stratus to apply to the cirrus-(*Page* 131) crowned cumulus. There is a particular kind of cloud distinctive of special, though rather uncommon, types of weather which would by many be called cirro-cumulus. It is a very high stratus, having numerous protuberances emanating from its upper surface. There is no cirrus about it. Their altitude is rarely less (*Page* 132) than 14,000 feet. They hardly ever occur in our islands, except in summer, and rarely then, unless the temperature is above the mean. They are rather more prevalent in the inland districts than elsewhere. They are usually seen near the western and south-western limits of an anti-cyclone when there happen to be one or more shallow depressions to the southward. They seem to be associated with vast electrical disturbances in the higher regions of the atmosphere, and they are very commonly the precursors of our grandest thunderstorms. This is especially the case when they move with great velocity from a south-easterly or southerly point, while clouds a little below them are flying from N.E. or E. Under these circumstances a single fragment of the cloud of this type, however minute, occurring in a bright sky, will enable an accurate observer to prognosticate thunder. These clouds sometimes disappear before the occurrence of a thunderstorm; the latter then takes place in the daytime, and is formed from the cumulus type already described. But there is a remarkable class of thunderstorms which come on with this kind of cloud. This cloud resembles ordinary stratus in one respect, that it glories in the night. Soon after sunset in a summer evening it often thickens and (*Page* 199) darkens in the S. and S.W., its under-surface being disposed in numberless wavy folds, through which, here and there, shine the highly-reflecting sides of its broken but cumulus-like turrets. Presently the sheet lightning begins to illumine the southern sky, while a light easterly or northerly breeze is felt below. In a few hours the storm is raging. Those of our summer thunderstorms which occur during the night are, with very rare exceptions, of this sort. When passing into the form which produces a shower, this cloud behaves like the ordinary shower-producing cumuli. Their summits run up so as to inosculate in some cases with cirrus at no great distance above them; in other cases their summits become spontaneously cirriform; and this change, probably accompanied by a neutralisation of electricities, is, so far as I have observed, the essential requisite of their precipitation (*Page* 134) in rain. The types of cloud opposite to the rain-bringing clouds are signs of fine weather. One cloud may be particularly mentioned as indicative of no rain. In summer the centres of anti-cyclones often comprise cloudless skies. A little stratus occurs at night, on some occasions at an elevation of from 4,000 to 10,000 feet, and this is developed into cumulus of moderate dimensions during the day. At a great elevation cirrus may often be seen in conoid tufts whose movement is extremely slow. In winter, on the other hand, neither cirrus nor cumulus is common near the centre parts of anti-cyclones, but the sky is rarely clear. A bed of nearly stationary stratus often covers the heavens for many nights and days in succession. This bed is frequently of vast extent, but of very small vertical thickness. Where gaps occur in it we observe a sky totally devoid of every species of upper cloud. Now we infer that there is over every anti-cyclonic area a slight general downward movement of the atmosphere. In the summer the sun's rays dissolve the stratus, (*Page* 135) and the rapid evaporation taking place during the long and hot days sends up the local or scattered patches of cumulus or cirrus. In winter this does

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not take place. The vapour in the very high regions of the atmosphere is carried by the descending current towards the surface of the earth; it probably, therefore, experiences a rise of temperature, and consequently does not pass from the gaseous into the visible form. The surface of the earth is, however, losing heat by radiation, and at an altitude of about 3,000 feet or less (often much less) above that surface a temperature is encountered which is low enough to condense the gas into a level sheet of vapour. The remarkable continuity of this sheet I imagine to be due to the fact that wherever a break in it occurs the earth beneath loses more heat by radiation, and the sheet is consequently speedily reformed. The air below is sometimes clear, sometimes foggy. Occasionally over a great expanse of country, and especially in the neighbourhood of our large towns, the atmosphere is obscured by thick fog, and the densest and darkest fogs of London are commonly those which occur beneath this anti-cyclonic stratus; these fogs being, possibly, due not only to the want of horizontal motion in the air, but partly also to the descending currents which accelerate the downward movement of the now water-laden particles of smoke. (*Page* 136) Although strati are usually more prevalent over sea than land, this stratus is much more continuous over the land than over the sea. It is also noticeable that the breaking up of one of these bands of stratus is usually the first sign of a change from settled to unsettled weather. The explanation offered accounts for both these facts. The relative warmth of the atmosphere over the sea in winter prevents the formation of stratus; and again, the cessation of the general descending currents, or the commencement of the ascending currents, necessarily attends the breaking up or the passing off of the anti-cyclone.

Lucas, Joseph. *Symons's Meteorol. Mag.*, vol. xiv. (*rsp.*) [Abstract of a paper read to the British Association.]

[No. for October.]

(*Page* 147.) Changes of temperature in the soil must act upon the contained moisture in the same way as they do on the air above, thereby tending to cause evaporation, or to produce percolation. In an abstract of more than 100,000 observations upon the temperature of the soil, made in the gardens of the Royal Botanic Society, London, 1871-1876, Mr. G. J. Symons observes that the heat-wave commences in March, and spreads downwards till the whole four feet of observation is warmer than the air in September and October, the effect of the preceding cold wave disappearing at four feet by the end of August. In November the cold wave commences, and moves down till the whole four feet is colder than the air by the end of February, when the heat wave begins again.

Morgan, E. D. *Journ. Roy. Geog. Soc.*, vol. xlviii. (1879) (*rs.*).

(*Page* 306.) Along the Urun-daria the atmosphere is so damp, that over the whole region there is a vegetation, consisting of saksaul (*Anabasis saxaul*), tamarisk, brambles, and, where the moisture is still greater, willows and reeds.

Moseley, H. N. (*B.*)

(*Page* 45.) On many mountains the distribution of plants is mainly dependent on the gradual increase of moisture with height (above sea level), as in St. Vincent (*Page* 226) and Ascension. In high Arctic latitudes there is little cooling at night, owing to clouds and mists preventing radiation.

Skertchley, J. A. *Journ. Roy. Geog. Soc.*, vol. xlviii. (*rs.*).

(*Page* 281.) In Wassaw the dry season commences from the end of August, and lasts till November. From December to May there is a short dry season.

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Symons, G. J., in *Modern Meteorology* (1879) (*rv.*).

(*Page* 138.) Each cubic foot of the air in the tropics may be said to contain roughly eight grains of vapour at the temperature of 76°. If that air be transferred to these islands, and be reduced to their average temperature of 50°, it must part with nearly half its vapour. When one substitutes for grains and feet, tons and miles, there is no difficulty in understanding why winds from those regions deposit rain on all colder countries over which they blow.

Symons, G. J. *Symons's Meteorol. Mag.*, vol. xiv. (*rsp.*)

[No. for November.]

(*Page* 163.) A lovely spot, embowered in trees and encircled by hills, is usually characterized by a damp, misty, cold, and stagnant atmosphere. These conditions (*Page* 164) are not adapted for vigorous health. Evaporation data would be serviceable in computing the yield of storage reservoirs. Data as to the amount of evaporation would be very useful in connection with sewage irrigation, for it ought, evidently, to be most successful where the air absorbs the largest amount of surplus moisture. Hygrometry is almost identical with the measurement of evaporation, but not quite, because hygrometry considers the amount of moisture in the air at rest, and evaporation is the resultant of the average of a variable number of miles of air of a variable hygrometric condition over a water surface. It is the business of hygrometers to tell us how much water [in the state of aqueous vapour] there is in the air. It is never very great; fifteen grains of water [in the state of vapour] in a cubic foot of air is the extreme, perhaps a trifle beyond the extreme, which ever occurs in this country [England], while it may run down to one grain per cubic foot.

Nature.

(*Page* 269.) Eliot has discovered that a cyclonic vortex when generated in the middle of the Bay of Bengal always travels towards that part of the coast where the wind velocity for the time being is least in comparison with the average velocity for the same place and time of year. This law lends a great deal of support to the theory that a cyclonic vortex is developed through the accumulation, concentration, and condensation of aqueous vapour over a region of comparative calm. (*Page* 299.) Dr. Mann at Society of Arts, January 21st, stated that when solar spots were abundant, more solar energy was thrown out, and this caused a larger amount of the water of the earth to be raised in vapour, which condensed to a greater (*Page* 326) rainfall. Montigny comes to the conclusion that it is the presence of water in greater or less quantity in the atmosphere that exerts the most marked influence on scintillation, and which most modifies the character of it, either when the vapour is dissolved in the air, or when it falls to the surface of the ground in the liquid state, or in the solid state in the form of snow. Prof. Asa Gray in *Am. Journ. Sci.* (*Page* 327) showed how the distribution of forests is mainly dependent on the distribution of moisture, and thus explained the great difference which exists in this respect between the eastern and western United States. Afterwards he shows how the distribution and nature of the North American forests are dependent mainly (*Page* 548) on moisture and temperature. Acad. Sci., Paris, March 31st. Colladon: In large hail storms the cumuli forming them are divided into several distinct groups, insulated electrically from each other by sections of cold air resembling smoke columns from several chimneys. The columns of hail the author conceives as a huge descending piston; hence the violent whirling movements of wind near the ground, and the descent of cold, dry, highly-electrified air from the upper regions. (*Page* 523.) Meteorol. Soc., March 19th. Dew, mist, and fog, by George Dines.

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He used watch glasses of known area and weight, and exposed them on grass, slate, and a deal board; the two latter were raised a few inches above the grass. A minimum thermometer was placed beside each glass. It is only on rare occasions that an amount of dew exceeding ·01 inch in depth has been deposited upon the measuring glasses, and out of 198 observations in only three has that amount been exceeded. Fifty-eight observations gave the amount of from ·01 in. to ·005 in.; 107 from ·005 in. to ·001 in.; 22 less than ·001 in.; and eight observations gave no dew at all. Dines thinks it may be fairly assumed that the average annual deposit of dew upon the surface of the earth falls short of 1·5 in. There are two kinds of mist, the morning and evening; the morning mist is caused by the evaporation from the water and the moist ground taking place faster than the vapour is taken away; the air becomes saturated, but this does not stop evaporation; the vapour continues to rise into the air, is there condensed, and forms mist, which gradually spreads over a wider surface. The evening mist is produced as follows. The cold on the grass caused by radiation lowers the temperature of the air above it; the invisible vapour of water previously existing in the air is in excess of that which the air can retain when the air temperature is lowered, the surplus is condensed, becomes a mist cloud, and floats in the air just above the surface of the grass. Taken either separately, or combined, the mists appear to be totally and altogether inadequate to account for those dense fogs which at times overspread the country. Dense fogs near the earth are often accompanied by a clear sky above. Dines would attribute these to some cause unknown, by which the whole body of air to some distance above the earth is cooled down, and as a consequence, part of the vapour in that air is condensed, and forms an 'earth cloud.'

Nature.

(*Page* 116.) Meteorol. Soc., May 21st. G. M. Whipple finds that at Kew the amount of sky covered with clouds varies inversely as the barometric pressure between the limits of 29·0 in. and 30·3 in., the variation being most rapid between 29·8 and 30·1 in. Also that above 30·3 in. cloud increases with increasing pressure, attaining the mean about 30·5, and rising above it at 30·6 in. Loomis (*Am. Journ.* (*Page* 270) *Sci.*, July 1879) examines the paths of storms advancing from the north and from the south. They present different characteristics. In those moving from the south, the southerly winds which accompany them are marked by a greater humidity and velocity, and excessive rainfall. The facts presented by these favour the idea that in a great storm the condensation of vapour is an efficient cause which controls the movements of the winds. The central depression of the barometer seems to be the result of a circulating system of winds, the most frequent cause of which is two or more areas of high pressure at considerable distances, often 1,400 miles from each other—differences of humidity and temperature being important agents in producing, but more especially in maintaining such a system of winds. We require then, to know what are the causes which bring about those areas of high pressure round a region of lower, though still high pressure, and the concentration of moister and warmer air over this region.

Symons's Meteorol. Mag., vol. xiv. (*rsp.*)

(*Page* 89). A. Cruickshank selected six elevated points at distances of about (*Page* 90) 5, 10, 20, 30, 40, and 50 miles from his station, and by means of these estimated the extreme limits of view in the middle of each day for twenty-one years. The paper concludes with the deductions drawn from the observations. The mean daily distance seen is only twenty-five miles. The mean number of days in the year on which a distance of fifty miles can be seen is ninety. The greatest mean daily

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distance seen increases for each month from January to July, and then decreases again from July to January. This monthly increase and decrease in the greatest mean daily distance seen corresponds respectively with the monthly decrease and increase in the humidity of the air. There is no regular relation between the monthly variations in the mean distance seen and the mean monthly amount of cloud in the sky.

[No. for September.]

(*Page* 122.) Dr. Grabham, in a paper read before the British Association, observes that the sirocco wind in Madeira is sometimes very dry; the temperature being 84° and the dew-point below freezing.

(*Page* 124.) H. Courtenay Fox, in a paper read before the British Association, concludes from the discussion of the observations at Greenwich that in the winter (*Page* 125) months cold tends to be synchronous with dryness, warmth with large rainfall; in the summer months cold tends to be accompanied by much rain, warmth by dryness; and that years of drought tend to assume an average temperature.

1880.

Aitken, J.

(*Page* 196.) Vapour must have some solid or liquid body on which to condense; the dust particles usually form the nuclei required. When there is much dust in the air, but little vapour condenses on each particle, and they become but little heavier, and easily float in the air. If there are few dust-specks each gets more vapour, is heavier, and falls more quickly. When the air is nearly pure, and only a few dust-particles present, then only a few cloud-particles form, and they are heavy, and fall like fine rain. He concludes that if there was no dust in the air there would be no clouds and no mists, and that the supersaturated air would convert every object on the surface of the earth into a condenser on which it would deposit. When there are many dust-particles they give rise to the light form of condensation which constitutes a fog, and therefore whatever increases the amount of dust in the air tends to increase fogs, and when the dust-particles are not so numerous the cloud-particles are larger, and settle down more quickly. The dust-motes seen in a beam of sunlight are not the active nuclei of fog and cloud-particles, but those which are smaller and invisible. The large motes may be active nuclei, but their number is too small to have any important effect. The products of combustion of gas and fire have great fog-producing power. The products from a clear fire and a smoky one give about equal fogging. Common salt when burned gave an intensely fog-producing atmosphere, but burned sulphur was the most active (*Page* 197) substance experimented on. Smoke descends during a fog because the smoke-particles are good radiators and soon get cooled, and form nuclei on which the water-vapour condenses. Falling smoke indicates a saturated condition of the air.

Archibald, E. D.

(*Page* 394.) [He gives tables showing the variations from mean of cloud for the year, summer and winter at various places]. The tables show that with few exceptions—1. The annual amount of cloud is below the mean at the epochs of the crests of the heat waves, and above the same at those of cold waves; 2. That the relation is of the same kind, but more marked when the results for the summer season alone are compared; 3. That the results for the winter show, in several cases, a tendency to vary in the opposite manner. The dates of the crests of the hot and cold waves, as given by Professor Smyth, coincide with and include the principal critical epochs of cloud variation. It would seem that the waves both of heat and of

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cold were partially dependent upon watery vapour and its transformations, the heat wave being in part the effect of an excess of sunshine, and the cold wave of an excess of cloud.

Blanford, H. F.

(*Page* 482.) The following is a possible explanation of the alternating oscillation of pressure between the Indo-Malayan region and the Russian plains. Among the best established variations in meteorology which conform to the sun-spot cycle are those of tropical cyclones, and the general rainfall of the globe, both of which imply a corresponding evaporation and the condensation of vapour. Now this variation of pressure evidently has its seat in the higher (probably the cloud-forming) strata of the atmosphere. It is then a reasonable inference that the principal agency in producing the observed reduction of pressure at the epoch of sun-spot maximum is the more copious production and ascent of vapour which may operate in three different ways: First, by displacing air, the density of which is three-eighths greater; second, by evolving latent heat in its condensation; and thirdly, by causing ascending currents. The first and second of these processes do not directly reduce the pressure, but only the density of the air-stratum while they increase its volume. In order, therefore, that the observed effect may follow, a portion of the higher atmosphere must be removed, and this will necessarily flow away to regions where the production of vapour is at a minimum—viz., the polar and cooler portions of the temperate zones, and more especially those where a cold, dry land surface radiates rapidly under a winter sky, such as the great plain of European Russia and Western Siberia.

Burder, G. F. *Symons's Meteorol. Mag.*, vol. xv., 1880.

(*Page* 29.) A rather remarkable hoar frost was observed here [Clifton] on the last two days of January and February 1st. Generally hoar frost is caused by the cooling of the ground below the temperature of the air by radiation. In this case the relatively low temperature of the ground was evidently occasioned by the slowness with which the earth, cooled by a long frost, became affected by the thaw then prevailing. This hoar frost differed also from others in the situations in which it was found, being scarcely less abundant on the roadways, pavements, and gravel-walks than on the grass. The roads were so white as to give the impression of a thin covering of snow. It was also deposited thickly on the perpendicular faces of walls. Another point noticed was its persistence during the day, notwithstanding maximum temperatures of 43° and 48°. The crystals were remarkable for their scale-like form.

Croll, James.

(*Page* 521.) But for the sea there would probably be no aqueous vapour, and consequently nothing to protect the earth from losing its heat by radiation. The surface of the ground would then fall to the temperature of stellar space if deprived (*Page* 522) of solar heat. The lowering of the temperature tends to diminish the amount of aqueous vapour contained in the air, and this in its turn tends to lower the temperature by allowing of freer radiation into space.

Croll, James.

(*Page* 191.) The reason why snow at great elevations does not melt is owing to the fact that the heat received from the sun is thrown off into stellar space so rapidly by radiation and reflection that the sun fails to raise the temperature to the melting point. At low elevations where the snowfall is probably greater and the amount of heat less than at the summits, the snow melts and disappears. This is probably due

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to the influence of aqueous vapour. At high elevations the air is dry, and allows the heat radiated from the snow to pass into space; but at low elevations a very considerable amount of the heat radiated from the snow is absorbed in passing through the air into space. A considerable portion of this intercepted heat is radiated back into the snow, and being of the same quality as that which the snow itself radiates, is on this account absorbed by the snow. This heat accumulates in the snow till melting takes place. Were the amount of aqueous vapour possessed by the atmosphere sufficiently diminished, perpetual snow would cover our globe down to the sea shore. The air is warmer at the lower level than the higher, mainly owing to the influence of aqueous vapour; were this reduced the difference would not be so great. The lower descent of the snow-line on the south side of the Himalayas, and on the east side of the Andes, which are the moister sides, is owing to the fact that the snow-fall is much greater on the moister side. Other things equal the snow would melt at a higher elevation on the moist than on the dry side. The dryness of the air will, in a great measure, account for the present accumulation of snow and ice on Greenland and on the Antarctic continent. These regions are covered with snow because the quantity melted is small, and this is owing to its being prevented from rising to the melting point, owing to the dryness of the air. (*Page* 192) In places like Fuego and South Georgia, perennial snow and ice are caused by the sun's heat being cut off by clouds and dense fogs. The upper surface of the clouds reflects the sun's rays into stellar space, while one-half of the heat which they do absorb is radiated upwards; the other half which reaches the ground is insufficient to clear off the winter's accumulation.

Dines, G. *Symons's Meteorol. Mag.*, vol. xiv. (*rsp.*)

[No. for January.]

(*Page* 191.) From observations with the microscope on slightly cooled brass surfaces during fogs or mists, I conclude that a good deal of the moisture occurring on surfaces is really a very fine rain, and that the annual deposit of real dew upon the surface of the earth does not exceed one inch. Can any correspondent give a definition of dry fogs? Are they caused by smoke, by some combination of the temperature of the air with vapour, or do they only differ in degree from other fogs.

Ley, Rev. W. C. *Aids to the Study and Forecast of Weather*, 1880. (*rv.*)

(*Page* 3.) The points of cirri frequently point downwards, especially in dry weather. When increasing, these clouds form an interlacing network or sheet of filmy ice-mist, which is often seen over one side of the sky, while the other remains (*Page* 4) temporarily clear. True cirro-cumulus at the highest level often accompanies dry and warm weather. The more massive cloud-forms commonly degenerate into the stratiform descriptions soon after sunset. A peculiar modification of stratus is common under certain conditions. It arranges itself in parallel, but ill-defined, bars transverse to the meridian, which often coalesce so as to overspread the sky. It only occurs with a somewhat tranquil atmosphere, and rarely with a very high or extremely low temperature, and it may be further distinguished by its uniformly sober tints, in which a bluish-grey predominates. It may be distinguished as 'dry weather stratus.' Cumuli may be regarded as a sign of great (*Page* 5) cold in the region above them. Fine weather cumulus has a moderate elevation, and a well-defined rounded surface. Its formation and dissipation is governed greatly by the temperature of the day, the cloud frequently beginning to show itself soon after sunrise, increasing till the hottest part of the day, then gradually diminishing, and eventually disappearing about sunset. This form of

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cumulus is comparatively uncommon over the surface of the sea in our latitudes, and it may often be seen from a great distance, marking the position of a coast-line or even of small islands. Showery weather cumulus is remarkable for the rapidity of its formation and disappearance, and for the readiness it displays to pass into other cloud forms. Large and well-developed cumuli are usually called thunder-clouds, from their prevalence in periods of electrical disturbance; but it is worthy of observation that electrical discharges never appear to take place in any form of cloud until its summit has begun to spread outwards or upwards in a more or less cirriform shape, and has exchanged its hard for a soft outline. When cumulus has thus attained a great size it becomes a shower-cloud. In this state it is commonly called nimbus, a term applied to this kind of cloud, as also to the extensive composite cloud-banks, and, indeed, to all forms of rain-cloud. Here the term nimbus will be restricted to the great banks of composite rain-cloud. Other descriptions of clouds have similar modifications to the pocky form of cumulus. Thus cirro-stratus not unfrequently exhibits pendulous banks or wreaths on its under-surface when the temperature of the lower region of the atmosphere is falling, and a colder wind is setting in beneath. Detached fragments of cumulus, particularly when near the earth, are often as irregular in contour on their lower surface as on their upper (*Page* 6) surfaces. Unusual clearness of the atmosphere is commonly taken as a token of impending rain or storm. Now, the removal of the dust particles with which the atmosphere, in settled, and therefore somewhat calm and dry weather, is much charged, is an early indication that either condensation of vapour, or rapid movements of air, or both, has begun to occur in regions immediately to the windward of the observer, and consequently that the latter is nearly within a system (*Page* 7) of atmospheric disturbance. It is commonly said that a rosy sky at sunset presages fine weather. This generalization will fail if taken as a rule; but if we take pains to draw an inference as to the distribution of aqueous vapour in the atmosphere from the colour of the sky, we shall find that the latter frequently furnishes us with information which may be employed as subsidiary to our principles, with much practical utility. The redness of the sun when near the horizon is due to diffraction. Particles suspended in the air, whether dust, smoke, or very minute globules of water, give a red colour to transmitted light. This is the reason why in large towns the sun, both rising and setting, nearly always appears red. In the country the red colour which the rays acquire in passing through a long stratum of air is probably, in large measure, due to water globules forming an extremely fine mist. At sunset, after the evaporation which has taken place during the day, these globules are usually present in large quantity at the time when the air is rapidly becoming cooler, and the sun, therefore, usually appears somewhat red. During the further cooling which occurs in the night, many of the particles are commonly deposited in dew, fewer remain suspended in the air, and the rising sun is therefore less usually red. A red sunrise indicates that after this precipitation the atmosphere still contains a large quantity of water-particles which, after the evaporation about to occur in the next few hours, is likely to form rain-clouds. A grey sky in the evening is commonly caused by the presence of an amount of cloud in the west, which is sufficient to stop the direct rays of the sun, and to allow nothing but diffused light to pass. The behaviour of secondary (*Page* 25) barometric depressions after they have reached the front of an advancing cyclone, seems to be ordinarily determined by the general atmospheric conditions of the district into which they have thus penetrated. If the barometric pressures in front are generally high, and the atmosphere dry, they become filled up, and disappear. (*Page* 26) If, on the other hand, the conditions are less favourable to their ulterior development, they commonly advance as independent cyclonic systems. It is (*Page* 27) probable that an ascending current of atmosphere occurs in the cyclonic

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observations, and that this ascending current originates in the simultaneous condensation of water-vapour over an extensive area. The district in which this condensation is most active occupies the point of the cyclone. A little consideration will show that over the north temperate zone, it is on the eastern side of a cyclone that this condition will in ordinary cases occur, since it is on this side that we have southerly winds, while these winds, in moving from warm to colder regions, experience a diminution in their capacity for holding aqueous vapour. A cyclone must, therefore, be regarded as an eddy of spirally ascending air, which eddy is being constantly reproduced on one side of its original position. An anti-cyclone, on the other hand, represents the position of a downward movement of the air, which has lost the greater part of the water vapour in previous cyclonic circulations. In the districts, therefore, near the central calm of an anti-cyclone, the currents take up, instead of precipitating, vapour. This explains why there is no principle of progressive development in an anti-cyclone, and why the cyclones, in their onward course, are not drawn towards the centres of the anti-cyclones, but skirt (*Page* 28) round the extreme exterior of the latter, for it is only the exterior currents of the anti-cyclones which have taken up sufficient water vapour to maintain the cyclonic disturbances. The same hypothesis accounts for the exceptional fact, already noticed, that in our region of the globe, a cyclone on the southern side of an anti-cyclone rarely moves westward, since in this instance the surface winds drawn into the cyclone from the anti-cyclone have not only been descending currents, but have also come from higher latitudes, and are therefore especially cold and dry. The tendency of the cyclones to skirt coast-lines rather than to travel towards inland districts is probably, in some measure, due to the fact that the vapour on which their maintenance depends is drawn principally from the seas. A secondary depression, according to this hypothesis, has its origin in a somewhat local nimbus, or in a local intensification of the general nimbus, and its in-flowing and ascending current is only an imperfect spiral. Again, the same hypothesis throws some light on the tendency which the cyclonic systems exhibit to run in a series—a fact which is difficult to explain, if a cyclone is regarded simply as a revolving disc. When the atmosphere over an extensive district of the globe, say over a portion of the North Atlantic to the westward of our islands, is much charged with water-vapour, the formation of a large nimbus is sufficient to originate a cyclonic system, but a considerable portion of the atmosphere which is drawn into the circulation never reaches the front of the cyclone at all, being left behind, as the cyclone is rapidly developed over another part of the earth's surface; this part of the atmosphere, therefore, falls calm before it has parted with its aqueous vapour, and is in the condition favourable for the propagation of another system. Other and converging lines of evidence in favour of this theory of cyclone and anti-cyclone may be drawn from the behaviour of these phenomena in other parts of the world, but the whole subject may be dismissed with one important observation, that neither the dampness of the atmosphere, as measured by the hygrometer, nor the amount of water collected in a rain-gauge, affords an adequate measure of the amount of cyclonic disturbance which attends a nimbus. The former instrument tells us nothing of the humidity of the atmosphere in general (*Page* 29), and the latter tells us nothing of the thickness of the atmosphere from which the water has been drawn. It is not surprising, therefore, that some of our shallowest cyclones are accompanied by as heavy and general a rain as the deeper systems, especially when it is observed that during sluggish circulations at the earth's surface rapid currents often exist in the higher cloud regions. An objection to the condensation theory of cyclones is occasionally drawn from the fact that, in some cases, both heavy and extensive rainfall is found to occur in the immediate rear of a centre of depression, when travelling eastwards. This may arise from the

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inclination of the axis of the cyclone, from which it will occasionally happen that over the wind which blows in the rear of a depression, currents flow in nearly an opposite direction to that wind. These latter currents consequently precipitate their water through the lower stratum of relatively dry air; the condensation being due to the fact that they are chilled not only by travelling from lower into higher latitudes, but by contact of their under-surfaces with air which is simultaneously (*Page* 30) travelling from still higher latitudes. In the front of a large depression (*Page* 31) at its extreme exterior there commonly stretches a great bank of cirro-stratus. The outside edge of the bank is pretty definite, and its outline in most cases is in rough correspondence with the contour of the advancing isobars. The movement of the upper current which carries the outlying parts of this elevated cloud-bank is often nearly tangential to the edge of the cloud-bank, and nearly opposite to the direction of the wind, which is presently about to spring up at the earth's surface, and in nearly all cases it makes a greater angle than 90° with this wind. As the sheet extends over us the upper current backs very quickly, and continues to do so over the whole of the front half of the advancing system. As the centre advances towards us we commonly observe composite cloud (nimbus), the rain or snow being accompanied by the new current of air belonging to the depression. This cloud bank extends in most instances nearly over the whole front half of the system, both on the right hand and left hand of the centre's path; but its character differs very considerably on the two sides. If the centre is passing so as to leave our station on its right, the nimbus usually continues until the centre has almost reached its nearest point to us. Then usually, after a sudden precipitation, the sky clears, the cirro-stratus terminating in an upright line, while the wind at the earth's surface begins to veer. The appearance of the sky in the rear of the disturbance, but still on the right side of the centre's course, is usually very unlike that in the front. Comparatively few upper clouds are observed, and the movement of these is commonly observed to be nearly the same with that of the current on the earth's surface. In lieu of cirro-stratus we see fleecy cumulus. Shower-clouds are also common over this district. These latter, in summer, especially in our more inland regions, often take the form of local thunderstorms. In winter, passing squalls of rain, snow, and hail are common. It should be remarked that these showers in the rear of a depression are far more extensive and persistent on exposed coasts and in hilly districts than in inland and more level countries. The atmosphere in this part of the disturbance is in most cases (*Page* 32) clearer or more devoid of haze than in the front. Suppose the barometric minimum leaves the station to the left of its course. Here the nimbus extends over us, and the wind after springing up commences to back, and continues to do so throughout the passage of the disturbance. On this side we rarely experience an abrupt change from a rainy to a clear sky. As the centre passes the higher cloud-forms degenerate into banks of dreary stratus, often attended with an increase rather than a diminution of haze. As the rear of the system approaches us on this side the bolder forms of cumulus are rarely seen, and in place of shower-clouds we commonly notice gloomy-looking banks of condensed vapour in the middle and lower levels of the atmosphere, while cirrus has usually almost or altogether disappeared. In the actual centre of a large depression the sky is often comparatively clear. Shower-clouds are frequently visible, but these have usually here a thin and disintegrated aspect, while cumulus tends to spread itself into stratus, and cirrus lies in broken, though watery-looking patches. The above description cannot be applied without considerable modifications to the smaller or more local systems. These latter are commonly characterized by a more unbroken cloud-bank, gloomy skies (often with rain or snow) prevailing over the central calm, and even to some extent over the extreme rear of the system. The secondaries are especially

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marked in most cases by very copious precipitation. In summer local depressions, especially if they are secondaries travelling northwards, are usually associated with heavy thunderstorms. In the front of these last-mentioned systems the cirro-stratus is commonly accompanied, and sometimes almost replaced, by the turreted stratus. (*Page* 33) In summer brilliant weather usually accompanies anti-cyclones, the dry air permitting the sun's rays to have full power. In the central districts particularly, the sky is often nearly or totally devoid of cloud; at other times light fleecy cirrus, whose motion is extremely slow, is the principal cloud visible. Near the exterior of the system, and especially on its eastern and south-eastern sides, stratus and fine weather cumulus, often accompanied by haze, are the prevailing cloud-forms. At the extreme western and northern borders cirro-cumulus and cirrus are very common beneath which there is fog, occasionally at the sea coast, but rarely at the inland stations. Near the south-western limit of a large and well-formed summer anti-cyclone remarkably cloudless weather often prevails. In winter the aspect of the sky is different. Dry-weather stratus is now the most common form of cloud, occasionally covering nearly the whole of the anti-cyclonic system with an unbroken canopy, the perpendicular thickness of which is very small, though its extent is so immense. Above this, in the higher regions of the atmosphere, there is, in such instances, a remarkable absence of cloud; while beneath it dense ground-fogs very commonly prevail at the inland stations. In some cases, however, the sky is almost devoid of cloud, or the ground-fog alone prevails. Near the extremity of the system the atmospheric currents usually break up, to a great extent, the canopy of cloud and land-fog. On the eastern and south-eastern limits of the system the appearance of the clouds is often very similar to that which prevails in the same district of an anti-cyclone in the summer; but banks of the dry stratus are even here more common than true cumulus. Occasionally, however, we experience, as in summer, an exceedingly clear sky on the south-western side of a large anti-cyclone, which in winter is accompanied by intense frost. It may be said generally that the occurrence in any marked degree of the form of cloud which has been distinguished as dry-weather stratus is commonly an indication of an anti-cyclonic movement of the air, and a thoroughly well-trained cloud observer can, in many instances, tell by a glance at the sky whether the wind at his station is anti-cyclonic or cyclonic in character. The following are examples of forecasts based on records of actual conditions:—1. Winter. In the rear right hand of a depression travelling to E. or N.E. Barometers moderately low, rising rapidly; brisk or moderate N.W. wind; clear sky between passing showers; very transparent atmosphere. No tendency to the formation of banks of stratus; little or no cirrus. As depressions commonly follow each other in a series, and as the direction taken by the last, as well as the absence of the more anti-cyclonic forms of clouds indicates the absence of any distinct anti-cyclone in the west, we expect the N.W. current shortly to fall calm, and to be followed by a fresh bank of cirro-stratus, decline of pressure, wind and rain. 2. Winter. After a day of chilly N. or N.W. winds, depression in the N.E., taking a S.E. course. Wind W. or W.S.W., brisk or moderate; atmosphere mild; barometer about the mean or below it, falling rapidly; cloudy, with flying scud, rough-looking composite cloud-bank, or dense cirro-stratus. The rapid decrease of pressure, in conjunction with the aspect of the sky, and with the previous weather, makes it probable that the right-hand segments of a cyclonic circulation travelling S.E. is about to pass over the station; N.W. to N. or even N.N.E. gale is, therefore, to be apprehended, with a great fall of temperature, and brisk recovery of pressure. 3. Summer. After moderately dry weather with westerly winds, and barometer about or rather above the mean (northern limit of an anti-cyclone). Barometer about the mean, and steady, or falling but little; wind S.W. or W.S.W., moderate or light; overcast, with much low cloud; temperature about,

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or a little above the mean, for the season. The right-hand portion of a depression taking a N.E. direction is probably passing over the station ; no rain, or but slight (*Page* 35) drizzling showers, may be expected ; the wind will most probably veer a little shortly, with a clear sky. 4. Winter. Extreme rear right hand of a large depression going E. or N.E. Calm, clear, and cold ; N.W. wind having died down, and cumuli and shower-clouds disappeared quickly ; sheet of cirro-stratus on S. horizon, edge travelling from W. or S.W. ; barometer below mean, rising, but rise checked somewhat. If the new cirrus-bank had appeared farther in the W., and its edge had moved from a more northerly point, the fresh depression which is probably approaching might have been expected to follow nearly in the wake of the previous system. As it is, however, there is risk of its centre passing on the S. side of the observer, causing a temporary easterly wind, perhaps gale on exposed coasts, with overcast skies, and probably some sleet or snow. 5. Winter. After light winds and dull weather. Barometer much above mean ; totally overcast with low, tranquil stratus, and nearly calm. As this is the central portion of an anti-cyclone no immediate change can be anticipated. 6. Summer. Barometer near its mean, but falling somewhat ; E. or N. breeze ; turreted stratus above, with some cirrus travelling rather briskly from a southerly point. A shallow depression is probably about to pass northerly over the station ; thunder and rain may be anticipated, followed by a light wind from some westerly point. 7. Summer. After westerly winds, with temperature and pressure near the mean. Decided rise of barometer, and very high temperature ; extremely clear and brilliant sky, with very few, and those only very low, soft clouds. Very light W. or N.W. breeze. The central part of an anti-cyclone moving slowly N.E. is likely to pass over the station. A further increase of temperature may be expected, followed probably by bright and hot easterly winds. 8. Winter. Extreme rear of depression moving to S.E. Steady rise of barometer ; wind veering from N.W. to N.N.E. ; hazy, with some dry-looking broken stratus, and no cirrus. An anti-cyclonic system may be surmised to exist over the W. or N.W. Fine and cold, though cloudy weather, may, therefore, be expected, with light winds. 9. Winter. After a period of disturbed weather, with cyclonic disturbances going easterly. Barometer about, or rather above the mean, scarcely falling ; continuous calm for some hours, with persistent and rather heavy rain. The observer seems to be near the centre of a very shallow depression, whose course is not distinctly towards E. or N.E. There is, therefore, a probability that anti-cyclonic currents are forming in the N. Much drier weather with a high barometer may consequently be, with some probability, anticipated.

Ley, W. Clement.

(*Page* 207.) Professor Poëy was one of the first to appreciate the importance of the terminology of clouds being based on the physical conditions to which the varieties are related ; but we know so little of these physical conditions that no (*Page* 210) satisfactory classification can be thus formed. That two distinct beds of clouds—the one at a high and the other at a low level—frequently exist when rain is falling, there is abundant evidence to show ; and perhaps this is especially the case during extensive intra-tropical rains. But observers are at least equally agreed as to the fact that a bed of cirrus may co-exist with a layer of low clouds, either with or without one or more intermediate layers, without the occurrence of rain or snow. And it is equally certain that the majority of passing showers are produced in a single mass of clouds, not necessarily, and perhaps never, homogeneous in structure in the portions near the earth, and in those which extend into the higher regions of the atmosphere, but certainly not divided into two ocularly distinguishable strata.

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Parfitt, Edward.

(*Page* 324.) Professor Sayce states that the Accadians supposed all kinds of astronomical phenomena to have an influence upon the clouds.

Rolleston, George. *Journ. Roy. Geog. Soc.*, vol. xlix. (1880) (*rep.*)

(*Page* 320.) Robert Rawlinson, in a lecture on Meteorology delivered in November 1868, said that evaporation has only an indirect and incidental reference to the land, its real dependence being in the great ocean and still greater sun. The powers of man can never seriously modify cloud in reference to the world at large. (*Page* 348) Professor Koch, following Ebermayer, says a great deal has been written on the evaporation of plants, of which much is intrinsically self-contradictory. Unger says water gives off three times as much vapour as a tree (? surface for surface); Schleiden that the tree gives off thrice as much as water. Koch says such observations and results are of no scientific value; but I consider they are valuable as they are reducible to weight and measure; and also that they have a distinctly appreciable practical value and applicability. Professor Wellington (*Page* 349) Gray tells us that 3,000 square mètres of cabbage leaves will give off as much as a pint of water per diem. It may be objected that the rate of evaporation observed in an isolated mass of leaves or in a single isolated tree does not give us a measure of the rate at which the same process will go on in a wood when the exposed and evaporating surface is relatively so much smaller; and this difficulty, which lies in the geometrical nature of the case, may account for the great discrepancies in the estimates which various writers have given of the amount of watery vapour given off by masses of wood. Pfaff gives 120 kilogrammes as the entire amount evaporated by an oak with 70,000 leaves, each of a square surface of 2,325 millimètres during the period from May 18th to October 24th. Vaillant gives the amount of watery vapour given off by an oak of 21 mètres height, and 2·63 mètres girth at a height of 1 mètre above the ground, as 2,000 kilogrammes on a fine day. Hartig calculates that a German morgen (=2·3895 acres), carrying a thousand trees of nine different sorts of conifers and broad-leaved trees of twenty years' planting, exhale daily during the period of vegetation at least 3,000 lb. weight of water. Professor Prestwich (*Water-bearing Strata*, 1851 p. 118), gives as an estimate for the amount of watery vapour given off by leaves of a tree of average size 2½ gallons per diem. Lawes, in *Journ. Hort. Soc.*, vol. v. (1858), states that three plants of wheat or barley gave off 1½ gallons, 250 grains of water for every grain of solid residuum in the adult plant. Hellriegel gives as his estimate that for the production of 1 lb. of dry barleycorns, 700 lbs. of water, inclusive of the water evaporated from the soil, are all that is necessary, and that other cerealia have their demands limited within somewhat similar proportions. It must, however, be allowed that the cases (*Page* 350) of the drying up of springs as a consequence of cutting down trees are more numerous and better established than the increase of springs by this operation. The explanation of this apparently self-antagonizing or capricious operation of the same primary cause is not far to seek. When a tree is cut down the area once protected by its leaves is exposed to the uncounteracted action of the summer sun, and rainfall may run off it when hardened, just as it runs off an imperfectly thawed surface in the spring, or it may sink away underground by fissures caused by the exposure, and under favourable conditions may give rise to a lake. Generally, one or more of the conditions favourable for this are wanting, and then the diminution of wood goes hand in hand with the diminution of water. Viollet le Duc notices the marked influence of forest destruction in bringing about a diminution of glaciers (*Page* 351), but is unable to say what the connection is. I think the loss of the trees as evaporating agencies is the true cause of the diminution. The cerealia, with their deep roots, are quantitatively pre-eminent for the amount of aqueous vapour

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they give off. An area of wood must give off much more vapour than an area of glacier, and would, by the vapour it set free into the atmosphere, save the glacier from wasting. In mountains the influence of forests in increasing rainfall may count for something considerable, whilst in the plains, howsoever well wooded, trees can act only, as do other good radiators, in the way of precipitating, not wind-borne, moving vapour, but simply dew. Any one may observe in a mountainous district how—

> 'The swimming vapour slopes athwart the glen,
> Puts forth an arm, and creeps from pine to pine,
> And loiters slowly drawn.'
>
> TENNYSON: *Œnone.*

The term 'Rauchen der Wälder' is used for the smouldering of the clouds amongst trees. In a lowland or other country frost hangs on such a tree as the birch long (*Page* 353) before it has begun to whiten the ground round it. What is the source of the larger amount of vapour above pines than broad-leaved trees? Does it come from the soil; is it the result of evaporation from the leaves; or is it due in the coniferæ to the action of thousands of points which the whorls of their leaves develop every year? This is a complex question which the present data do not enable us to answer. It is clear the transpiration of the leaves cannot by itself produce this phenomenon, since the transpiration in coniferæ is less active than it is in broad-leaved trees. It follows, then, that if the vapour of water dissolved in such great abundance in the atmosphere enveloping the pines was the result of the evaporation of the trees, this phenomenon ought to be much more striking over the mass made up by the broad-leaved trees than in that made up by the coniferæ, whilst observation shows that exactly the contrary is the actual fact. We must, therefore, ascribe to the soil and to other unknown causes this remarkable property which pines have of attracting watery vapour. If it had appeared from M. Fautrat's tables that this excess of watery vapour was more marked in rainy than in dry times, it would have been easy to explain the fact by figuring to ourselves, the all but infinite area which the fine films of water clothing every needle-shaped leaf of a coniferous tree would make up and offer for evaporation. For the leaves of our common coniferæ wet readily; and it is owing to this property I apprehend that they intercept as much as one-half the rain which falls upon them before it reaches (*Page* 354) the ground, whilst broad-leaved trees intercept but one-third. But, as it appears the coniferæ possess the hygrometric advantage independently of the rainfall, the phenomenon does require some additional information, and may perhaps find it in the theory of the cause of rain proposed by J. A. Rowell in 1839—viz., that electricity increases the buoyancy of aqueous vapour particles. A good conductor would cause rain or dew or mist by drawing off the electricity from the particles; the pointed pine-leaves would very much favour the action.

Smyth, Piazzi. (See *Biby.*)

(*Page* 194.) Angström showed that some of the dark lines at the red end of the sky-spectrum were due to watery vapour. He has found that these lines increase in darkness according to the quantity of vapour present in the atmosphere. This (*Page* 195) band precedes D. A sudden darkening in it denotes a large amount of extra moisture, which is likely to be deposited in rain. The spectroscope is then a ready means for detecting rapid changes in the amount of aqueous vapour in the air. This can be done with the smallest spectroscope. With larger ones the group called 'little *a*, and its preliminary band,' with its myriads of black lines, forms a still more powerful rain-band.

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Tait. (See *Biby.*)

(*Page* 340.) Seen from a distance, the mass of cloud belonging to a thunderstorm usually presents a most peculiar appearance, quite unlike any other form of cloud. It seems to boil up from below, and to extend through miles of vertical height. The estimated height, at its lower surface, above the ground varies within very wide limits. Saussure has seen it as much as three miles, and in one case noticed by De l'Isle it may have been as much as five. On the other hand, at Pondicherry and (*Page* 438) Mandli it is scarcely ever more than half a mile. Ordinary auroras are thought to be due to the condensation of aqueous vapour in far less quantity, but through far greater spaces, than the quantities and spaces involved in thunderstorms.

Woeikoff, A. (See *Biby.*)

(*Page* 250.) I think I have proved that, as to what we call the temperature of the air (really that of the lowest stratum), it is, on the equator and a few degrees north and south of it, far more influenced by the yearly distribution of clouds and rain than by the amount of heat received from the sun. The result would be different if we knew the temperature of the whole stratum of air. The heating of the whole surface of the clouds by the sun, and especially the heat liberated by the condensation of water, must give to the higher strata a superior temperature than that they had in the dry season; in other words, the decrease of temperature with elevation is much slower where the sky is cloudy and rain is abundant in the greater part of the year; so that in such regions the temperature of the whole air may be higher than in drier climates. I consider water to be the only direct cause of the mildness and uniformity of equatorial temperatures, and this in three ways: (1) By the great heat capacity of water; (2) by the clouds which interpose a screen between the sun and the surface of the earth; and (3) by the evaporation of rain-water by the soil and plants. The two latter are especially powerful on the land, even very far from the sea. If it was not for the clouds and evaporation how could we explain, for example, the absence of great heat (hottest month 78·6°) at Iquitos on the Amazon in 4° S., and more than 1,000 miles from the Atlantic? Where the sky is clear and humidity and rain deficient very high temperatures of the air are attained even at great distances from the equator (10° to 30°), notwithstanding the prevalence of winds from colder regions.

Nature. (See *Biby.*)

(*Page* 220.) Acad. Sci., Paris, December 15th, 1879. On the influence of rain currents traversing them, and the affinity of pines for vapours, by M. Fautrat. On an average the weight of aqueous vapours contained in 1 cubic metre above pines is 8·66 grammes, and on bare ground at the same height 7·39 grammes, showing 1·27 grammes in favour of the pines. Above leafy trees the corresponding numbers are 8·46 grammes and 8·04 grammes; difference in favour of leafy trees 42 grammes.

Nature. (See *Biby.*)

(*Page* 355.) There are fogs and fogs—from the one extreme of the dry fog of continental meteorologists which merely blur the sky with a bluish-tinted mist and shears the sun of its brilliancy as it nears the horizon, so that the eye can look on its disc undisturbed, to the other extreme of our London fogs. Fogs appear under (*Page* 356) widely different conditions. The last touch in the character of fogs is contributed by smoke, as explained by Sir John Herschel, whereby each particle of soot, acting as as insulated radiant, collects dew on itself, and sinks rapidly through the fog as a heavy body, thus giving to London fogs their yellow, thick consistency, and the suffocating and unwholesome sensation experienced in breathing them.

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Nature. (See *Biby.*)

(*Page* 363.) Meteorol. Soc., January 21st, Report. The great local differences in humidity require to be more accurately ascertained than they are at present, not only at seaside places, but in inland districts in their relation to hills and valleys. The council have decided to establish a third set of stations, to be called climatological, at which observations of humidity, clouds, etc., are taken daily at 9 A.M. C. Greaves advocated a more attentive inquiry into the subject of hygrometry. The appearance and disappearance of vapour, its diffusion, its origin in and withdrawal from the vapourous forms, were matters which could now be readily defined through (*Page* 503) the increased supply of good observations. Loomis finds that storms advancing from the Rocky Mountains to the Atlantic pass from a drier to a more humid atmosphere; whereas in Europe those going east pass from a humid to a drier atmosphere.

Nature. (See *Biby.*)

(*Page* 594.) Loomis finds that dry air, even when greatly heated, has but little ascensional force, and that the violent uprising of heated air so frequently witnessed in moist climates is mainly due to the large amount of aqueous vapour with which it is charged. Buchan (*Journ. Scot. Meteorol. Soc.*) remarks that the maximum daily period of the summer thunderstorms in Scotland coincides with the hour when the ascending columns of heated air from the earth's surface are in full activity, and the result is, no doubt, largely due to the circumstance that these ascending masses of heated air develop a charge of electricity as their moisture condenses into cloud. The period of maximum frequency of the winter thunderstorm occurs some hours before and some hours after midnight, or during those hours of the day when the vapour-laden wind of the Atlantic approaches to and reaches its diurnal maximum temperature, and when, consequently, the condensation of the vapour may be expected to reach its daily maximum.

Nature. (See *Biby.*)

(*Page* 48.) Acad. Sci., Paris, November 2nd. Faye says that in paroxysmal eruptions the enormous amount of steam ejected causes volcanic thunderstorms. (*Page* 96) Meteorol. Soc., November 17th. 'Table of Relative Humidity,' by (*Page* 204) Edward F. Dymond.—Lister's experiments show that a single drop of rain develops organisms in sensitive solutions which would otherwise have remained unaltered. Hence germ-producing matter, or the germs themselves, form at least a part of the cloud- and fog-producing dust.

Symons's Meteorol. Mag., vol. xv.

[No. for February.]

(*Page* 2.) Signor Capello finds that the mean of the rain gauges on a tower seventy-five feet high, one on the windward, and the other on the leeward side, is almost the same as that collected by a gauge in an open space five feet above the ground. He concludes that the difference between the higher and lower gauges depends on the force and direction of the wind.

(*Page* 3.) Prof. Poëy first suggested his new classification of clouds at a meeting of the Acad. des Sci. at Paris, in 1863; a fuller paper was read before the Meteorol. Soc. of France, translated into Spanish, and published in Mexico, then developed and printed in English in two or three publications in the United States. It then appeared in the Report of the Smithsonian Institution for 1870, under the title of 'New Classification of Clouds.' Two years after it was further developed and published in the *Annales Hydrographiques* with the title 'Nouvelle Classification des Nuages,' and now it appears as 'Comment on observe les Nuages.'

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[No. for March.]

(*Page* 19.) At the Australian Meteorological Conference in November 1879, it was proposed that the mean humidity curve be derived from the means of maximum and minimum of wet and dry bulb thermometers. In this country [=England] maximum and mininum wet bulbs are scarcely ever used, because the maximum of the dry bulb and of the wet bulb not being necessarily synchronous, the difference between them is not always, if indeed, often a true indication of the actual (*Page* 20) difference between the dry and wet at any given instant, and the same argument applies to the minimum. In the absence of self-recording dry and wet thermometers we should have preferred to take the mean of the humidity at 3 A.M., 9 A.M., 3 P.M., and 9 P.M., obtaining the former from one of Nigretti's turnover hygrometers.

The Conference resolved to consider and report on observations to determine the difference in humidity by self-registering maximum and minimum thermometers, and by other methods; and as to the best method of determining spontaneous evaporation.

[No. for April.]

(*Page* 40.) M. Masure read a paper at the Easter meeting of scientific men at the Sorbonne in 1880, entitled, 'Observations on the Evaporation of Water, and on the Transpiration of Plants.' He remarked that even when air was damp (say the humidity not above 80) moisture is often deposited on the earth, that the consumption of water by plants is not wholly due to evaporation from their leaves; that the true amount of evaporation is at present badly determined, but that [it] is really merely a question of the interchange of vapour between the clouds and the earth, dependent on their respective temperatures. This view the author developed in a formula, by which he said that the amount of evaporation could be computed from ordinary meteorological readings. The velocity of the wind is not included in the formula.

[No. for May.]

(*Pages* 49-51.) [Gives criticisms on the skies depicted in pictures at the Salon, Paris, and Royal Academy, London. The artists' names are intentionally not given, the pictures being indicated by numbers and title. The criticisms seem to give very little meteorological information, and to relate rather to artistic success or failure in depicting skies and clouds. Hence the notes are here considered to belong to Art and not to Climate.]

[No. for December.]

(*Page* 160.) If water, or matter containing water, be warmer than the dew-point of air resting upon it, the water will evaporate; and if the air be colder than the water the vapour in the air may become saturated with invisible vapour, and may, in addition, contain globules of water too minute for their weight to cause them to fall to the earth as rain, and which globules, breaking up the transparency of the atmosphere, produce what is called mist or fog. Similarly, but inversely, if warm saturated air passes over ground which is much colder than itself, its capacity (*Page* 162) for retaining, in an invisible form, all the water in it is lessened by its own loss of heat, and the water which it cannot hold invisibly changes into the globular form, and so again we have the transparency of the air destroyed. This second explanation carries with it the identity of cloud and fog, and accords with the cloud formation known as 'pennants' from many isolated mountain peaks, and with the 'table-cloth' of the Cape of good Hope. So much for fogs in general, the damp white normal fog of all parts of the world where fogs exist at all.

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1881.

Aitken, John. (See *Biby.*)

(*Page* 312). Mr. Russell's difficulty with regard to fogs in large towns is due to his not taking into account the amount of vapour in the air. The atmospheres of the towns which do not have fogs are drier than that of London.

Aitken, John. (See *Biby*).

(*Page* 384). He describes Coulier's experiments by which he discovered the part (*Page* 385) played by dust in the condensation of vapour. Coulier found the products of combustion to be active as condensers of vapour. This he attributed to unconsumed carbon. He found air after rain and storms less active, and the air of summer less active than that of winter. Coulier also made experiments rendering inactive gases active by means of combustion. He concludes that the explanation of these phenomena has to be found; but seemed to attribute the activity to the heating of the air.

Broun, J. A. (See *Biby*).

(*Page* 558.) Aqueous vapour cannot explain the annual oscillation of pressure, since it is just when the tension of vapour is greatest that the barometric weight is least. The introduction of more vapour into the atmosphere does not make the whole lighter, but heavier; and when we subduct the vapour pressure from the barometric height, we find the oscillation to be greater, not less, than before. It is not easy to determine the vapour pressure from the indications of the dry and wet bulb thermometers; but its amount will not explain the annual law, nor will it explain the independent oscillations in question. I have, however, suggested that the humidity of the air may be in question, and as the oscillations of dryness or humidity of the lower mass are probably related to (*Page* 559) the temperature, the oscillations of pressure may be related to them. I would suggest that the pressure of the atmosphere is affected by gravitation and some other attracting force, such as the electric attraction of the sun, depending upon the varying humidity of the air, and this again depending on the temperature.

Capron, J. R. *Symons's Meteorol. Mag.*, vol. xvi. (*rsp.*)

(*Page* 181.) I began daily records of observations with the spectroscope on the rain-band on July 1st, 1880, and have continued them till now (November). The history of the rain-band may be said to date from the time when Angström's maps of the solar lines were found to present different aspects according to the conditions (*Page* 182) of moisture of the atmosphere at the time of observation, and when that pioneer of spectroscopy proved the presence and absence of certain lines forming bands in the spectrum, more especially a set near D to depend on that condition. No practical meteorological result followed, however, until, as Prof. P. Smith tells us, the subject was first presented to him as a marked feature in sky spectrum at Palermo before and after a sirocco in 1872. [References are made to Smyth's papers on the subject.] In February 1878, appeared vol. xiv. of the *Edinburgh Astronomical Observations*, 1870-77, in which the subject is fully treated. He has contributions in Nos. li., lii. of the *Journ. of the Scot. Meteorol. Soc.* McClean's star spectroscope is a useful instrument for these observations. (*Page* 183) Having obtained the instrument, close the slit, and adjust the focus till the lines in the spectrum are sharp and clear. This should be done on a bright part of the sky. Then point the instrument to the quarter of the heavens which it is desired to examine, and note results, especially as to lines D and their neighbourhood. I generally observe thus at 9 A.M. daily from my laboratory window (looking towards the south); but if time and opportunity allow, three observations at 9 A.M., 1 A.M., and 5 A.M., would be better, varying the parts of the sky tested; and

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I examine with the spectroscope elevated about 13°. Prof. Smyth recommends to point as low as you can to the horizon, provided you get transmitted light, and to observe when the sun is neither high nor low. I find in practice 9 A.M. a good time to make observations when only a single one is taken daily, and also that if I get too low on the horizon I am apt to have a false band, due to earth moisture. In observing you will soon remark change in the character of some of the spectrum lines as compared with those seen on a blue sky, with an elevated spectroscope, and moreover, bands of varying intensity are found added to the low spectrum not seen in the higher one. The lines and bands that change their character, or are variable in their appearing, are telluric; either rain-bands or lines, called by Prof. Smyth 'a function of moisture and temperature,' or low sun-bands and lines, distinguished by him as 'a function of dry air and low sun.' The true solar bands remain unchanged. For meteorological purposes generally it will suffice if examination is confined to the principal band on the red side of D. In enumeration of the darkness of the band for the purpose of record, I use from Nos. 1 to 5, as under: 1, means faint; 2, faint to moderate; 3, moderate; 4, moderate to strong; 5, strong. Prof. Smyth uses the enumeration 1 to 10, but I have found a difficulty in distinguishing when so many degrees are used, especially when the intensity of the light varied. Simultaneous observations of the other meteorological instruments should be made, and the circumstances of sun, sky, and clouds noted. Drawings are given of the rain-band as seen by the spectroscope [but are not reproduced here]. They are thus described:—1. Spectrum as seen upon a pure high sky. 2. Spectrum observed January 17th, 1881, 8 A.M. Morning dull, red sunrise; low sun-bands and lines strong; no rain-band. 3. Spectrum observed 24th August, 1881, 8 A.M., showing moderate low sun-bands and lines, and a faint rain-band and lines weak. Rain-band moderate. 5. Spectrum seen December 9th, 1880, 8 A.M. Sun shining through watery clouds; low sun-lines strong. Rain-band strong. 6. Spectrum seen July 6th, 1881: Rain-band everywhere and exceptionally strong, stretching nearly half-way between C and D. Whole spectrum darkened, and obscured. The rain-band's action is hygrometric, and involves the general principle that according to the amount of suspended moisture in the air so [is] its appearance and strength. A faint, or faint to moderate rain-band, may, in some cases only, show an amount of moisture which will remain suspended for some time. A moderately strong, or strong rain-band, represents an excess of suspended moisture which, before long, is sure to descend [as rain]. Prof. Smyth mentions instances, and I have met with several myself where an apparently perfect (*Page* 185) transparent sky showing rain-band has, on a change of temperature, condensed, as it were, into clouds which have poured. A little while since (August) I observed only a faint, or at most a faint to moderate, rain-band, on a beautiful blue sky, studded with white cauliflower innocent-looking cumuli. I predicted wet, and at mid-day meal was twitted with the sunshine and brightness; but sure enough in the afternoon down came the rain. On the other hand, it will sometimes be raining, and yet only a slight, perhaps no, rain-band shows; an effect generally connected with a cold wind, north or east. No rain-band is also sometimes observed when the wet and dry bulb readings only slightly differ; but the explanation of this may be that low earth moisture affects the bulbs, which is not recognised in the sky-directed instrument looking through a thin stratum of it. [He gives some diagrams and observations which show the relation noticed between the rain-bands and rainfall during several periods.]

Groneman, H. J. H. (See *Biby.*)

(*Page* 337.) Messrs. Coulier and Mascart obtained the same results as Aitken in 1875 (*Naturforscher*, p. 400; *Journ. of Pharm.* [4] xxii., p. 165). In my 'Théorie

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cosmique de l'Aurore polaire,' I have pointed out the importance of these results on the relation between aurorse and clouds. If the invisible aqueous dust is able to reach much higher regions than terrestrial dust, and if aurorse are in close connection with cosmical matter in a state of extreme division, this cosmical matter is without any doubt enabled to form aqueous clouds in a much higher than the usual level. In *Gœa*, in 1873, it was noticed that the dispersed iron and other vapours derived from combustion in the higher regions must form on cooling a fine precipitate, and may form conducting channels for the aurorse. Secchi, in 1872, noticed the peculiar structure of the cirrus seen during the auroral display, particularly their orientation, which indicated the possibility of such position being due to their magnetic qualities. Microscopic meteorites often occur in hailstones (*Comptes Rendus*, 1872, p. 683).

Preece, W. H. (See *Biby.*)

(*Page* 336.) A confirmation of Aitken's theory of fog occurred in a friend's house at Streatham, on the occasion of the place being filled with steam from the bursting of a boiler. Wherever a cold surface was found the vapour condensed, and left behind it black carbon dust. Nowhere else was this dust found. The snow of London in thawing becomes dirty, owing to the dust and carbon being left behind.

Russell, R. (See *Biby.*)

(*Page* 267.) According to Mr. Aitken's theory, fogs should be common wherever large quantities of fuel are burnt; and all large towns should have urban fogs. Before coal was used Paris did not have more fog than the surrounding country. (*Page* 268) Philadelphia, which burns anthracite, rejoices in a transparent atmosphere. The great coal and iron districts of South Wales are free from fog. A humid atmosphere is not necessary for the production of mist and haze. The frequent long-continued prevalence of blue haze over the whole country, not excepting the east coasts, in the driest east winds of spring, would be a subject deserving investigation. They sometimes extend to a height much above the tops of our highest mountains.

Whipple, G. M. *Symons's Meteorol. Mag.*, vol. xvi. (*rsp.*)

(*Page* 39.) F. N. Shaw is now conducting an investigation on hygrometry and hygrometers on behalf of the Meteorological Society. He adopts Schwackhöfer's hygrometer as his standard of reference. Schwackhöfer concludes that the only correct way of estimating the amount of aqueous vapour in the atmosphere is by chemical methods. Of these methods there are two: analysis by weight, and analysis by volume. Hitherto the first has been the only plan adopted, but it involves much trouble, and gives the average humidity for a lengthened period of time, not the humidity for any given moment. The volumetric method is free from this objection, and may be worked with a comparatively simple apparatus, kept ready to hand, and capable of giving the desired result with accuracy in a few minutes. As to the degree of delicacy required it may be remarked that as 0·1 mm. (*Page* 40) (0·039 in.), of vapour tension represent about 0·013 per cent. of the volume of aqueous vapour in the air, the apparatus should indicate with certainty the change of one-hundredth per cent. or one ten-thousandth part in the volume of air measured. Although Schwackhöfer first constructed his instrument for the particular purpose of determining the humidity of the air at different levels in forests, and comparing it with air at similar heights in the open country, yet he considers that it may be equally well employed in place of the ordinary pschycrometers [= psychrometers] for daily observations at meteorological stations, since it is always ready for immediate use, and without much calculation will give the humidity, the operation occupying ten minutes or a quarter of an hour. The

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principle is to measure the volume of air, and repeat the measurement, after the air has had its moisture abstracted by means of sulphuric acid, under the same conditions. In the case of fog the air is slightly heated before it is passed into the apparatus, so that the watery vesicles may be converted into vapour. [A sketch and description of the apparatus is given, and details as to how it is worked.]

Nature. (See *Biby.*)

(*Page* 260). Acad Sci., Paris, January 3rd. 'Facts for the Study of the Formation of Fogs,' by M. André. A high barometer was observed to sink suddenly (with rain) while a fog present disappeared. With a slow rise of the barometer the fog (*Page* 370) reappeared.—The report of the Government Gardens at Rangoon and the attempt made at West African settlements indicate that the vegetation of tropical (*Page* 398) Australia will not thrive in a humid climate.—Dines (*Zeits. f. Meteorol.*, xv., p. 381) estimates the annual dew formation to be about 35·5 millimètres (on grass 26 mm.); at the best 38 mm. Average nightly on grass ·07 mm.—Meteorol Soc., (*Page* 427) February 16th. 'Relative Humidity,' by C. Greaves. The term frequently leads to misunderstanding. He suggests other tables with a more correct denomination. Roy. Soc. Edinburgh, February 7th. Aitken communicated further experiments on the formation of fogs. He found the same results were obtained at very low temperatures (down to 8° F.) as at higher ones. In dry fogs—that is, fogs formed in non-saturated air—certain kinds of fog-forming dust were much more efficient in their action than others. Some, in virtue of their deliquescent properties, formed clouds in non-saturated air; others only acted in saturated air; while a third class (*Page* 490) required the air to be super-saturated. At Mexico the hottest time of the year is the driest, the mean relative humidity for April and May for 1878 and 1879 being only 42.

Symons's Meteorol. Mag., vol. xvi. (*rsp.*)

[No. for May.]

(*Page* 65.) At the Annual Réunion des Sociétés Savantes in Paris Prof. Alluard suggested that Saussure's hair-hygrometers should be graduated in accordance with the indications of the dew-point by one of Alluard's hygrometers occupying the same space. M. Garban read a paper on the rate of evaporation. He experimented with a series of vessels filled with various earths and regularly weighed. The evaporation from chalk was less than that from sand; in fact, the latter appeared to collect most dew and vapour, and also to yield its vapour more readily than any other variety of earth. M. Hébert considers that the fœhn and sirocco are produced when, under the influence of a great Atlantic storm, a current of warm humid air moving rapidly impinges on a chain of mountains which compels it to dilate and to become cooler, and therefore to produce a larger fall of rain. When the air reaches the top of the mountain it contains only the quantity of vapour necessary to saturate it at the low temperature to which it fell during its ascent, and falling down the other slope with a circular or spiral motion, it becomes warmed by the compression, and as much drier as it is warmer. When the point of the system reaches the plain the gyratory descending motion and the centrifugal force jointly produce a diminution of pressure, which gives rise to an internal gyratory ascending current of considerable force, which produces the low pressure found in the centre of the storm. A complete storm thus consists of two parts: an interior region of low pressure, where the air is ascending in conical spirals, and an external area of high pressure and descending spirals. The air in the cyclones becomes rapidly more damp, and thus, while commencing with a very dry air, they finish with (*Page* 57) violent winds and torrential rains. He traces these features in all the cyclones and great storms which occur in the best-known storm regions.

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M. Masure read a paper on 'New Researches on the Evaporation of Water and on the Transpiration of Plants.' The abstract supplied by himself differs much from the notes we took. According to the abstract, arable lands influence evaporation mainly by the manure they contain, which renders them more retentive of water. According to our notes he stated that the amount of evaporation could be determined by a formula containing values for (*a*) temperature of the water; (*b*) temperature of the air; (*c*) temperature of solar radiation; (*d*) humidity of the air; (*e*) velocity of the wind. He then exhibited one of a series of fifty-one charts, on each of which he had placed curves giving hourly observations of all the meteorological instruments which he possessed. The air temperature was taken by a thermometer swung round in the air, and the same thermometer was subsequently used to ascertain the temperature of the water in the evaporators. His observations were made in a garden rather full of plants. He found the temperature of the water at sunrise always below that of the air. He considered that the temperature of stagnant water was different from that in a river where it was tossed about. During the early morning hours he not infrequently found that, instead of evaporating, condensation had taken place on the surface of the water in his evaporators. He found the range of temperature of the water in one day as much as from 49° to 85° F. or 36° F. He had also made experiments as to the amount of evaporation from a tobacco-plant, and found that the hourly amount (*Page* 68) passing off was markedly less when the sky was overcast; the life and breathing of the plant were, in fact, checked by want of sunshine, the influence of which was greater even than that of heat.

[No. for October.]

(*Page* 155.) Baldwin Latham, in a paper read before the British Association, noticed that the levels of springs rose or fell inversely with the barometric pressure (*Page* 156), and did not seem to be influenced by the hygrometric state of the air, as was suggested by Prof. Hughes.

1882.

Boerner, C. G. (See *Biby.*)

(*Page* 482.) Evaporation commences at sunrise, and continues until the diurnal temperature has attained its maximum, between 2 and 4 P.M. As the decrease of temperature progresses more rapidly from 4 to 9 P.M., than during the remainder of the night, it is evident that a large proportion of the vapour suspended in the heated air during the day is precipitated as evening dew, and frequently by 10 P.M., the deposit on the foliage of trees becomes so copious that it may be heard falling in drops from leaf to leaf. Another period in which dew is copiously deposited is after midnight and at the dawn of day. After 9 P.M. the rate of decrease in atmospheric temperature is considerably retarded, but when the temperature has arrived at its minimum the deposition of dew is augmented. The appearance of dew only in the morning proves that the temperature of the evening was not reduced to the temperature of the dew-point. A hazy atmosphere, or a large amount of invisible vapour, will retard radiation; hence serene cloudless nights, without deposition of dew, are regarded as indications of coming rain. According to the (*Page* 483) theory of Prof. Henry, the deposition of dew depends upon the stillness of the atmosphere.

Finley, John P. (See *Biby.*)

(*Page* 4.) The place of origin of cyclones is between the belt of calms and the south limit of the trade winds, or say, briefly, in the vicinity of 10° N.—50° W. This region coincides with the zone of constant rainfall, where evaporation is very rapid, cloud formation exceedingly brisk, the air almost constantly saturated with

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moisture, and heavy condensation a regular feature of the day. Typhoons form south of the Tropic of Cancer, and in the vicinity of the Philippine islands. The same remarks apply to this region as in the case of cyclones. The general direction of movement of the tornado-cloud is invariably from a point in the S.W. quadrant to a point in the N.E. quadrant. The tornado-cloud assumes the form of a funnel, the small end drawing near to or resting upon the earth. This cloud, or the moving air of which it is the embodiment, revolves about a vertical axis with inconceivable rapidity, and always in a direction contrary to the movement of the hands of a watch. The destructive violence of the storm is sometimes confined to the immediate path of the cloud, as when the small or tail end just touches the earth. While, on the other hand, as the body of the cloud lowers, more of it rests upon the earth, the violence increases, and the path widens to the extreme limit. The tornado (*Page* 5), with hardly an exception, occurs in the afternoon just after the hottest part of the day, and generally disappears before the going down of the sun. The (*Page* 6) hour of greatest frequency is between 3 and 4 P.M. When I speak of the formation of a water-spout at a considerable height in the air, I mean that the (*Page* 7) embodiment of the whorl, or the revolving current of the air, first appears in a dark cloud of minutely divided particles of water, the result of rapid condensation of course in the air, and therefore in the water. Hailstorms are characterized by a strange cloud-formation, and a peculiarity of precipitation unlike any other formation in the category of storms. The cloud from which the hail falls is basket-shaped, with a dark and portentous exterior, a ragged and ominous-looking opening at the bottom; and within a whirling conglomeration of snowflakes, pellets of snow and ice, partly formed, and perfect hailstones. The hail-cloud forms between the currents of the upper and lower regions of the atmosphere, and moves forward in the plane of these currents, either within or just above the upper limit of the lower atmospheric regions, where it finally disappears, and the deposition of (*Page* 9) hail ceases. The tornado is preceded by the formation of a large barometric trough, with a prevalence of northerly and southerly winds at each end. Carefully study cloud development, colour as well as form, also manner and direction of approach. The approach of a cirrus-cloud (perhaps at a height of six to eight miles) from the S.W. is very significant, and is the evidence of the gradual but certain advance of the upper south-west current, which eventually plays so important a part in the development of the tornado-cloud. Clouds are but the embodiments of air currents, yet they are full of meaning. A study of the upper currents of the atmosphere would be impossible without their manifestations, and that, too, in a variety of forms. Wind direction, temperature, and clouds are the proper subjects of observation and thought by the isolated observer [of tornadoes]. (*Page* 10) While the conditions preceding a tornado are forming, the winds north and south of the main axis of the trough cause an increasing contrast of temperature. This contrast increases with rapidity, and the formation of cloud commences in earnest. Huge masses of dark and portentous appearance bank up in the N.W. and S.W. with amazing rapidity. The struggle for mastery in the opposing currents is thus indicated by the gathering cloud formations. The condensation of vapour from the extremely humid southerly currents by contact with the augmenting cold of their struggling opponents continues. It increases rapidly. Finally, when the tenacious hold upon a stable equilibrium can no longer be maintained (which is controlled by the rapidity and extent of condensation), the opposing forces are, as it were broken asunder, followed by the upward rush of huge volumes of air. The outward indication of this event is first shown in the whirling, dashing clouds over the surface of the heavy bank of condensed vapour forming the background. The next stage is the gradual descent of the funnel-shaped cloud from a point apparently just beneath the position of the enactment of the first scene. One pre-

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(*Page* 11) monitory sign is excessive sultriness of the air. Other signs equally important and reliable may be found in the development and peculiar formation of the clouds in the western horizon. Sometimes these peculiar clouds extend from the S.W. through the W. by the N. to N.E. More frequently they form in the N.W. and S.W., sometimes commencing first in the former quarters, and then again in the latter; but in either case they are equally significant. The marked peculiarity of the cloud is found to occur not only in the form, but in the colour and character of development. The sudden appearance of ominous cloud, first in the S.W. and then almost immediately in the N.W. or N.E. (perhaps the reverse in the order of their appearance), generally attracts attention. In almost all cases these premonitory clouds are unlike any ordinary and usual formation. If they are light their appearance resembles smoke issuing from a burning building or straw-stack, rolling (*Page* 12) upwards in fantastic shapes to great heights. Again like a fine mist, or quite white, like fog or steam. Some persons describe these light clouds as at times apparently iridescent, or glowing, as if from their irregular surfaces a pale, whitish light was cast. The dark clouds at times present a deep greenish hue, which fairly forbodes the greatest evil. Again they appear jet black from centre to circumference, or in a change of form this deep-set colour may only appear at the centre, gradually diminishing in intensity as the outer edges of the cloud or bank of clouds are approached. Sometimes these dark clouds, instead of appearing in solid and heavy masses, roll up lightly, but still intensely black, like the smoke from an engine or locomotive burning soft coal. They have been described as of a purple or bluish tinge, or at times possessed of a strange lividness. Frequently dark green, again an inky blackness. One observer says: 'The clouds seemed to be boiling up like muddy water, the upper surface of the cloud reminding me of the incessant eddies or whirls seen in the muddiest portions of the Missouri river.' Others thus: 'I saw two whirling circles of lightish-grey clouds in the west; they were acting independent of each other, and moved slowly inward toward each other from opposite directions. The clouds were very low, seemed to be on the earth, the wind in contrary directions across the face of the western sky, and surrounding clouds in great profusion.' 'I saw a green-looking cloud in the N.W., surrounded by others not so deep set in colour. Under the cloud from the S.W. there came a large number of little thunder heads, some very dark, but others as white as steam. They seemed to be separated, and running very low. I never saw clouds so low before. Pretty soon they began to go in all directions—some up, some down, right and left, backwards and upwards. I next saw a cloud that looked even all over in colour, and very white, the edges pretty even. It moved remarkably steady, and seemed to be right under the edge of the cloud from the S.W.' 'Two clouds, one from the N.W. and the other from the S.W., seemed to meet, and after meeting passed still lower. Above (*Page* 13) their place of meeting black smoke appeared in very peculiar shape.' The peculiar action of the clouds while they are forming is another interesting and significant feature, which should be carefully watched. There seems to be some strange connection between the almost simultaneous appearance of clouds in the S.W. and N.W. As they approach from opposite directions, they are suddenly thrown into the greatest confusion, breaking up, as it were, into small portions, which dash pell-mell over each other, and in every direction, now darting towards the earth, now rushing upward to considerable heights like the ascension of a sky-rocket, or at moderate elevations rolling over each other in a well-developed whirl. An observer in describing the approach of the clouds from the S.W. and N.W. stated that they 'came together with a terrific crash, as if thrown from the mouths of cannons.' Generally, following closely upon the existence of this condition, the funnel-shaped tornado-cloud appears against the western sky, moving boldly to the front from without this confused mass of flying clouds. As the tornado cloud

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advances these scuds continue to play about its top and sides, constituting a (*Page* 15) characteristic feature of the scene. The tornado cloud is, generally speaking, funnel-shaped; that is to say, the lower end is always the smallest. It may appear to be balloon-shaped, basket-shaped, egg-shaped, like a kite or a bulb, or an elephant's trunk, etc. The major axis may be inclined to the perpendicular, but is usually upright. Sometimes it is hour-glass-shaped, and then the tornado is extremely violent. The variations of form are important in a critical study of the tornado. They depend upon the peculiar whirling movements of the air.

Schwedoff, Theodore. *Symons's Meteorol. Mag.*, vol. xvii. (*rsp.*) Paper read before the British Association.

[No. for November.]

(*Page* 149.) Hail comes from very characteristic clouds, sometimes dark, almost black; at other times very bright, but always dense, with clear cut and agitated outlines; we recognize them amongst storm clouds. The same character of clouds is repeated in the falls of meteorites. It is suggested that hail is of extra-terrestrial origin.

Symons's Meteorol. Mag., vol. xvii. (*rsp.*)

Notice of Professor Pöey's 'Les Courants Atmosphériques,' etc. A translation is given of a portion of Chapter I., from which the following remarks are selected:—

(*Page* 99.) We proved in a previous volume that the form of clouds is due to their integral structure, which is inseparable from the physical constitution of the various layers of the atmosphere, where the action of weight, pressure, heat, and humidity undergo constant changes, indicated by the presence of special formations of clouds; that there are two characteristic types of cloud,—the cirrus, formed of frozen particles, and the cumulus, formed of watery ones; all other forms are evolved from these two types; that there exists in the evolution of clouds a scale of complication or increasing speciality from the upper region of the cirrus down to the fracto-cumulus near the surface; that one may regard the atmosphere in a vertical sense as divided into two great regions, each having physical characteristics and meteorological products quite distinct; that usually the Pallio-fractus forms the boundary between these two layers. It is at this intermediate layer, where the watery particles are changing into snow or ice, that the meteorological manifestations are developed. In the regions below this are produced thunderstorms, rain, snow, hail, the easterly trades, surface winds, and optical phenomena dependent on reflection, such as rainbows and coronæ. The general movements of the atmosphere have their origin in the upper regions, as have also equatorial storms, the westerly trades, and optical phenomena dependent on refraction, such as haloes, parheliæ, and paraselenæ. Accordingly heat and moisture prevail in the lower regions, cold and dryness in the upper; and hence the formation and structure of the clouds. In the upper regions the vapour of water is precipitated in the form of ice needles, and in the formation of cirrus; in the middle region in that of snow crystals and cirro-cumulus; and in the lowest region in that of watery particles and of cumulus. The atmosphere may therefore be regarded as consisting of a series of concentric beds of constantly varying properties, and in which the clouds are modified from the cirrus or cumulus to an extent corresponding with their altitude. From the altitude alone it is therefore possible to determine the physical constitution of the stratum and the characteristic forms of cloud, and *vice versâ*. The elements are all intimately related, and the knowledge of any one enables us to deduce the others. When observers are thoroughly persuaded of the truth of these facts they will have a powerful guide in their observations of clouds, they will recognize the importance of employing a nomenclature in harmony with the present state of science, and perhaps they will adopt that which we have proposed.

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[To this the reviewer adds]:

(*Page* 102.) Is it possible that the reason that shepherds and fishermen are such good weather prophets is that they study the form and character of the clouds, and that in their rough way they get a truer insight than do those excellent observers who determine that the mean amount of cloud at 9 A.M. is 6·7, and at 9 P.M. 7·1 ?

[No. for August.]

(*Page* 104.) It seems to follow from the figures given by M. Fautrat that the degree of saturation of the air by moisture is much greater over masses of leafed species of trees than others. [See under 1880 *Nature*, xxi., Notes.] The leafage and branches of leafed trees intercept one-third, and those of resinous trees the half of the rain-water which afterwards returns to the atmosphere by evaporation. On the other hand, these same leaves and branches restrain the evaporation of the water which reaches the ground, and that evaporation is nearly four times less under a mass of leafed forest than in the open, and two and one-third times only under a mass of pines.

1883.

Abercromby, Hon. Ralph. *Symons's Meteorol. Mag.*, vol. xviii. (*rsp.*)

[No. for February.]

(*Page* 11.) There are what are called good and bad hours for clearing; that is to say, that if during a rainy day the sky breaks about 11 A.M. or 2 P.M., the improvement will not last, so that these are bad hours. If, on the contrary, the break occurs about noon or 4 P.M., it is expected that the weather will clear permanently; and these are called good hours of clearing. These are the hours which hold good (*Page* 12) in Scotland, but perhaps they vary in different parts of the country.

Backhouse, T. W. *Symons's Meteorol. Mag.*, vol. xviii. (*rsp.*)

(*Page* 58.) Since 1858 I have registered foggy weather, using as a gauge the distance at which objects can be seen. The scale is as follows:—

Distance visible,	32	miles	Fog, 4
,, ,,	8	,,	,, 8
,, ,,	2	,,	,, 16
,, ,,	880	yards	,, 32
,, ,,	220	,,	,, 64;

and so on in inverse ratio to the square root of the distance visible. The objects observed are any solid bodies in the daytime, and at night ordinary gas-lights. The visibility depends on the distance, not upon the angle subtended by the object; (*Page* 59) size and colour have little influence on visibility. A good deal depends upon height, since the atmosphere is usually clearer high up than low down. I therefore select objects which are approximately of the same height. I found a difficulty in deciding upon a scale. Distance alone would not do, nor a scale of simple inverse ratio, since then there would be no perceptible difference between a moderately clear day and a very clear day. Perhaps a logarithmic scale would be fairer than any, such as :—

Distance visible,	32	miles	Fog, 6
,,	16	,,	,, 7
,,	8	,,	,, 8
,,	4	,,	,, 9

and so on.

Crosby, W. O. *Appalachia*, vol. iii., No. ii. (1883). Read December 18th, 1882 (*rv*).

(*Page* 132.) In East Cuba the sky is usually clear till the sea breeze or N.E. trade-wind strikes the mountains in the middle of the forenoon. Then the watery

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vapour is condensed, and clouds (usually cumuli) begin to appear. The cloudiness increases until a continuous cloud-belt is formed, extending east and west as far as the eye can see, but always of very limited breadth. From any moderate eminence, or from a mile or two off the north coast, it can be distinctly seen that the clouds do not extend far south of the summit of the range, enveloping the high peaks and ridges, while through the low passes clear sky appears beyond; but towards the north the cloud-belt may cover the shore, or extend several miles out to sea. On many days, especially in the dry season, the clouds do not form a distinct and continuous belt, and their development is not followed by rain. When the land breeze sets in at night the cloud-belt is carried out to sea, and may often be seen in early morning resting on the northern horizon before it is dissipated (*Page* 133) by the advancing sun. Except during the prevalence of general storms the precipitations take place on the north sides of the mountains, the clouds rapidly disappearing in invisible vapour as they are carried by the trade wind over the heated southern slope.

Dines, W. *Symons's Meteorol. Mag.*, vol. xviii. (*rsp.*)

(*Page* 107.) I have had a meter in use since January. I send a specimen of the results obtained with it :—

		TENSION.	
Dry bulb.	Wet bulb.	By calculation.	By meter.
60·5 [degrees]	57·8 [degrees]	·439 [inches]	·302 [inches]
64·5 „	58·8 „	·418 „	·263 „
64·0 „	57·4 „	·387 „	·249 „
64·0 „	56·6 „	·367 „	·223 „
64·8 „	56·5 „	·355 „	·205 „

The method is to take a given volume of air, extract the vapour by means of sulphuric acid, restore the air to its original volume and temperature, and note the loss of pressure. The tension thus obtained is less than that given by the tables; and I have no doubt that further investigation will show that the tension of vapour mixed with air, and not in the presence of water, is less than is generally supposed.

Gladstone, J. H. *Symons's Meteorol. Mag.*, vol. xviii. (*rsp.*)

[This paper is regarded as belonging to 1883. It, of course, strictly belongs to 1863, and when the paper is read in the original publication, it is possible some facts not given here would be entered on account of priority of statement.]

(*Page* 19.) The paper is based on observations on fogs made at about 250 stations. Prof. Tyndall defined a cumulus as the visible capital of an invisible column of saturated air. When on the summit of the Righi one morning last summer [=1862], there lay in the valley of the Reuss a mist like a white sheet on the ground, but as the sun began to exert his power, and a light breeze to spring up, the uniform layer began to break into regular masses, and soon far beneath us there stretched a cirrus-cloud, identical in aspect with those one often sees in the (*Page* 20) highest regions of the atmosphere. It is difficult to draw a line of distinction between fog and mist. The value of meteorological returns depends on this, and it appears that what one observer calls fog another describes as mist or haze. Mr. Cunningham suggests that when a pole, painted vermilion, placed at 100 yards distance, is rendered invisible by mist, such mist should be called a fog. Some months are marked by fogs more than others. For instance, along the south coast of England, February and September are comparatively free, while January and June are foggy months. November is notorious for fogs in London, but does not seem to deserve that character elsewhere. Some years are much more visited by fogs than others. For instance, 1861 was freer than 1858 along most parts of

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the coast. England does not deserve that pre-eminent character for mistiness which is attributed to it by the popular imagination of the Continent. A fog is more uniformly distributed over the surface of the sea than on the adjoining coasts.

Robie, David. *Symons's Meteorol. Mag.*, vol. xvii. (*rep.*)

[No. for January.]

(*Page* 184.) In past generations it was the common opinion that the rain-clouds were supplied with their water from neighbouring seas. The old agricultural reporters of the counties often spoke of a certain quantity of rain coming with the west or south-westerly wind from the Atlantic Ocean, and again so much being brought by an east wind from the German Ocean. They obviously attached little significance to what is termed a drying wind or a sunny day, or perhaps thought that the evaporation from the soil in the shape of aqueous vapour passed into space. The washerwoman, though a capital judge of a drying day when suspending her wet clothes, would take no account of what became of the moisture which disappeared in the process of drying. From observations with rain and (*Page* 185) Dalton gauges made at Bedford in 1882, I find that the water in the rain gauge measured 28·42 in., while the amount in the Dalton gauge, representing the amount which percolates the soil, was 14·50 inches. Hence almost one-half of the rainfall passed upwards into the atmosphere in an imperceptible form. The percentage which the percolation amounts bore to the rainfall in the several months was—January, 83; February, 50; March, 68; May, 54; June, 20; July, 51; August, 8; September, 40; October, 46; November, 67; and December, 94. (*Page* 186) Dalton gauges of various depths are in operation at Rothamsted, from which it is found that the moisture in the soil is drawn up from considerable depths. One gauge is five feet deep.

Tomlinson, Charles. *Symons's Meteorol. Mag.*, vol. xviii.

(*Page* 117.) Pictet made observations on the temperature at 5 feet and 79 feet (*Page* 118) above the ground in 1779. He found that the lower thermometer marked a lower temperature than the upper during the night. The difference was observed at all seasons during moderate and in cloudy weather; only in the last case the effect was much less appreciable. When the sky was completely clouded or fog prevailed the difference disappeared, both thermometers reading alike. Prevost, in 1772, correctly expounded the action of clouds in limiting radiation.

Symons's Meteorol. Mag., vol. xviii.

(*Page* 18.) We regret that no systematic records have been kept of the amount of fogs. We can only recall three short papers on fog distribution—two in the British Association Reports for 1861 and 1862 and the abstract of Dr. J. H. Gladstone's lecture to the Royal Institution on 'Fogs and Fog Signals.' [The latter is reprinted, and notes from it are given separately under Gladstone.] What is the (*Page* 21) best mode of determining the density of a fog? Dr. Gladstone mentions Mr. Cunningham's suggestion of a vermilion-coloured post. Why vermilion? Surely black and white would be a better contrast. The visibility of the pole will depend upon the background. The background should be uniform. Hence we think a broad board painted with stripes would be better than a pole. Further, the pole should face the south at all stations. In towns a distance of 100 yards may not be available, and we do not think so great a distance is needed. It appears to be desirable and practicable to obtain something more precise than a mere record of fog or no fog, according as one special object is or is not visible, and we should like to see an apparatus which by day or by night would indicate no fog, slight fog,

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moderate fog, dense fog. Mr. Cunningham's pole cannot be assumed to be more than 4 in. in diameter, and such a pole at the distance of 100 yards would subtend the very small angle of 3′ 49″. The measure of obscuration depends on the angle subtended by the object, and a black line 0·4 in. broad on a white board at a distance of 30 feet would subtend the same angle of 3′ 49″. As Dr. Gladstone says that such a pole as has been proposed seems to correspond with the ordinary definition of fog, we might accept its equivalent or (0·27 in.) ¼ in. at 20 feet as the breadth of No. 1 on the fog scale; and the subsequent numbers might be multiples of it—viz., ¼, ½, 1, 2, and 4 in. Our board would be horizontal, so that all parts of the (*Page* 22) scale should be under identical conditions, and it should, we think, never be less than 5 nor more than 10 feet above the ground. The scale figures should be painted above the lines. At night fogs may be gauged by street lamps or by means of small lanterns fitted with a composite candle and having a groove into which from one to four thicknesses of coloured glass could be dropped. In the densest fog such a light without any glass would be invisible at about 30 feet (perhaps at 20 feet, but we are not sure), and the density of the fog would be determined by placing the lamp at a distance of 20 feet with all the thicknesses of glass superposed, and removing them one by one until the light becomes visible; *e.g.*, if when all four were in the light could be seen, there would be no fog; with three in it would be No. 1; with two, No. 2; with 1, No. 3; with none in, No. 4; and if the naked light could not be seen, it would be a maximum fog, or No. 5. Of course (*Page* 38) all the lanterns must be alike and the glasses of equal tints.—The Rev. W. C. Ley has issued a circular of a scheme for the observation of the upper clouds, in which he suggests the outlines of a cloud classification. He objects to the terms cirro-stratus and cirro-cumulus as leading to confusion. In point of structure the clouds usually called cirro-cumulus belong essentially to the higher strati forms, consisting of nubecules separate or partly coalescing, occupying a layer of atmosphere of very small vertical thickness, but of very great horizontal extent, and they are not formed in nature by the processes which are productive of clouds either of the cirrus or of the cumulus type. The different varieties of cirriform clouds are described, with the symbols proposed for their designation. By means of a regular staff of observers information may be obtained as to the forms of the higher clouds, which will double the value of existing storm warnings; enable an isolated observer to plot out the general distribution of atmospheric pressure, and of the weather existing in the British Islands at the time of observation; form a forecast of what such distribution and the weather will be in the ensuing twenty-four hours; and furnish early information of coming storms. Mr. Ley's nomenclature seems to be too complicated for cloud observers.

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AQUEOUS VAPOUR,

BIBLIOGRAPHY.

1875.

1. **Abercromby, Hon. Ralph.** On the heat and damp which accompany cyclones. Q. Journ. Meteorol. Soc., January, II., pp. 274—276. 1875 (*ra*).
2. **Blanford, H. F.** Nature, xii., p. 189. 1875 (*rv*).
3. **Blasius, William.** Storms: their nature, classification, and laws, with the means of predicting them by means of their embodiments the clouds. 8vo. 1875. 10*s.* 6*d.*
4. **Harrison, J. P.** Notes on solar radiation in relation to cloud and vapour. Q. Journ. Meteorol. Soc. 1875.
5. **Rubenson, R.** On observations with the psychrometer. Q. Journ. Meteorol. Soc., III., p. 278. 1875. [Lib. Met. Soc.]
6. **Rubenson, R.** On Temperatur och Fuktighetsfoerhallenden i de nedersta luftlagern vid daggans bildande. 8vo. 1875.
7. **Smyth, P.** Nature, xii., pp. 282, 253. 1875 (*rv*).
8. **Wild, H.** On a simple evaporimeter, alike useful in winter or summer. Bull. Acad. Imp. Sci. St. Petersburg, xix. 1875.
9. Nature, xii., pp. 100, 224. 1875 (*rv*).
10. Nature, xiii., pp. 79, 899. 1875 (*rv*).

1876.

1. **Dove, H. W.** Monatliche Mittel für . . . Feuchtigkeit, . . . für 1875. 1876.
2. **Glaisher, James.** Hygrometrical Tables. 6th Ed. 8vo. London. 1876. 2*s.* 6*d.*
3. **Humber, Wm.** A comprehensive treatise on the water supply of cities and towns. Imp. 4to. £6 6*s.* London. [It has a chapter on rainfall and evaporation.] 1876.
4. **Marriott, W.** Contributions to hygrometry: the wet and dry bulb thermometers. Meteorol. Soc., December 20th, 1876.
5. **Meteorological Office.** Hygrometrical tables based on Glaisher's 5th Ed. For private circulation. 8vo. 1876.
6. **Miller, S. H.** On a self-registering atmometer. Q. J. Meteorol. Soc. 1876.
7. **Murphy, J. J.** Are we drying up? Nature, xv., p. 9. 1876 (*r*).
8. **Murray, D.** Nature, xv., pp. 76, 77. 1876 (*rv*).
9. **Rubenson, R.** On observations with the psychrometer. Meteorol. Soc., December 20th. (Trans. from the Swedish by Dr. W. Doberck.) 1876.
10. **Smyth, P.** Nature, xiv., p. 9. 1876 (*rr*). The warm rainband in the daylight spectrum [Edinburgh].
11. Nature, xiii., p. 520. 1876 (*rv*).
12. Nature, xiv., pp. 161, 162, 444, 562. 1876 (*rv*).
13. Nature. Are we drying up? xiv., pp. 527—528. 1876 (*rv*).
14. Symons's Meteorol. Mag., vol. xi., pp. 154, 156, 158, 159. 1876 (*rs*).

1877.

1. **Abercromby, Hon. Ralph.** On visibility. Q. Journ. Meteorol. Soc., pp. 294—298 (Jan. 1877). Paper read December 20th, 1876 (*rv*). [Nothing for these notes.]
2. **Alluard.** (Acad. Sci. Paris, September 17th.) Memoir on a new condensation hygrometer. 1877.
3. **Baumgartner.** (Imp. Acad. Sci., Vienna, April 12th.) Influence of temperature on velocity of evaporation. 1877.
4. **Bonavia, E.** Nature, xvii., p. 101. 1877 (*rv*).
5. **Broun, J. A.** Nature, xvi., p. 383. 1877 (*rv*).
6. **Brown, J. C.** Forests and moisture, or effects of forests on humidity of climate. 8vo, pp. 318. 10*s.* 6*d.* 1877.
7. **C., H.** Nature, xvi., p. 43. 1877 (*rv*).
8. **Czerny, F.** Nature, xv., pp. 239—240. 1877 (*rv*).
9. **Fautrat.** (Acad. Sci., Paris, August 6th.) Comparative influence of leafy woods and resinous woods on rain and the hygrometric state of the air. 1877.
10. **Hill, S. A.** Nature, xvi., p. 506. 1877.
11. **Ley, Rev. W. C.** Nature, xv., pp. 254, 334. 1877 (*rv*).
12. **Marriott, W.** (Meteorol. Soc., June 20th.) Describes Bogen's hygrometer. 1877.
13. **Symons, G. J.** Alluard's condensation hygrometer. Nature, xvii., p. 28. 1877.
14. **Schwackhöfer.** (Imp. Acad. Sci., Vienna, December 20th.) On a new apparatus for direct volumetric determination of the moisture of the air. 1877.
15. Nature, xvii., p. 14. A new condensation hygrometer [Alluard's]. 1877.
16. Nature, xv., p. 210. W. Marriott (Meteorol. Soc., December 20th, 1876). Contributions to hygrometry. The wet-bulb thermometer.—Hon. R. Abercromby. On visibility. 1877 (*rv*).
17. Nature, xvi., p. 369. Temperature and humidity of the air at different heights (*rv*). [Abstract of Dr. Hamberg's observations published in Trans. Roy. Soc. Sci., Upsala.] 1877.
18. Nature, xvi., pp. 295, 336, 392, 541. 1877 (*rv*).
19. Nature, xvii., pp. 134, 135, 156. 1877 (*rv*).

1878.

1. **Abercromby, Hon. Ralph.** Q. Journ. Meteorol. Soc., p. 143 et seq. (No. for July.) 1878 (*ra*).
2. **Archibald, E. D.** Nature, xvii., p. 505. 1878 (*rv*).

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3. **Broun, J. Allan.** Nature, xviii., pp. 126—127. 1878 (*rv*).
4. **Hildebrandsson, H.** Appeal to meteorologists to make observations of clouds. Zeits. f. Meteorol., xiii. 1878.
5. **King, Samuel.** Dense fogs. Symons's Meteorol. Mag., vol. xiii., p. 176. 1878 (*rs*).
6. **Koppe, K.** Die Messung des Feuchtigkeitsgehaltes der Luft. Zürich. Zeits. f. Meteorol., February 15th. 1878.
7. **Lockyer, J. N.** Nature, xviii., p. 224. 1878 (*rv*).
8. **Mascart.** (Acad. Sci., Paris, March 4th.) Influence of electricity on evaporation. 1878.
9. **Montigny.** Further researches on the scintillation of the stars. Nature, xviii., p. 292, 293.—Bull. Acad. Roy. Sci. Belgique. 1878.
10. **Murray, A. E.** Symons's Meteorol. Mag., vol. xiii., p. 161 (*rs*).
11. **N., J. H.** Nature, xviii., pp. 672—673. 1878 (*rv*).
12. **Schwackhöfer.** Zeits. f. Meteorol., vol. xiii., p. 241. 1878.
13. **Thomson, Sir C. Wyville.** Nature, xviii., p. 449. 1878 (*rv*).
14. **Watson, W.** (Meteorol. Soc., June 19th.) Notes on some remarkable cloud formations accompanying sudden and frequent changes of temperature and wind. 1878.
15. **Whitmee, S. J.** The Southern Drought. Nature, xvii., pp. 447 [refers to the Samoa and Gilbert Islands], 486 [refers to Gilbert Island]. 1878.
16. Nature, xvii., pp. 385—386. 1878 (*rv*).
17. Nature, xviii., pp. 288, 292, 352, 680. 1878 (*rv*).
18. Nature, xix., p. 178. 1878. Clouds and weather signs, by Rev. W. Clement Ley (*rv*).
19. Symons's Meteorol. Mag., vol. xiii., pp. 55, 91, 167, 169 (*rs*).

1879.

1. **Cantoni, G.** Sugli evaporimetri e sulla temperatura dell'aria. Ann. dell' Ufficio Cent. Meteorol. Italiana. Serie II., vol. i. 1879.
2. **Cantoni, G.** Some reflections on a recent note of Jamin on the theory of dew. Rendiconti Lombard., xii. 1879.
3. **Cruickshank, Alexr.** On the horizontal visual penetrability of the atmosphere or the extreme limits of view along the earth's surface. Journ. Scot. Meteor. Soc., vol. v.
4. **Erskine, St. V.** Journ. Roy. Geog. Soc., xlviii., p. 28. 1879 (*rs*).
5. **Hind, J. R.** Nature, xx., p. 189. 1879 (*rv*).
6. **Howard, L.** Essay on the modifications of clouds. 3rd Ed. 1879. 4to. 11*s*.
7. **Ley, Rev. W. C.** Clouds and weather signs in "Modern Meteorology," pp. 102—136. 1879 (*rv*).
8. **Lucas, Joseph.** Symons's Meteorol. Mag., vol. xiv. (No. for October), p. 147 (*rs*).
9. **Mann, R. J.,** in "Modern Meteorology." 8vo. London. 1879 (*rv*).
10. **Miller, S. H.** The prevalence of fogs. Symons's Meteorol. Mag., vol. xiv. (April), pp. 39—40. [Refers to Lowestoft and Wisbech] (*rs*).
11. **Morgan, E. D.** Journ. Roy. Geog. Soc., vol. xlviii. (1879), p. 306 (*rs*).
12. **Moseley, H. N.** Notes of a Naturalist on the *Challenger*. 1879 (*rv*).
13. **Posy, A.** Comment on observe les nuages pour prévoir le temps. 3rd Ed. Paris. 1879. 8vo, pp. 5 and 179. 4*s*. 6*d*. [The earlier editions had a different title.]
14. **Skertchley, J. A.** Journ. Roy. Geog. Soc., vol. xlviii., p. 281. 1879 (*rv*).
15. **Symons, G. J.,** in "Modern Meteorology." 1879 (*rv*).
16. **Symons, G. J** Symons's Meteorol. Mag., vol. xiv., pp. 163—164. 1879 (*rs*).
17. **Volland.** Ueber Verdunstung und Insolation. Ein Beitrag zur bessern Kenntniss d. Hochgebirgsklimas. 8vo. Basle. 1879. 1·6 marks.
18. Nature, xix., pp. 269, 299, 326, 327, 523, 548 (*rv*); xx., pp. 116, 270 (*rv*). 1879.
19. Symons's Meteorol. Mag., vol. xiv., pp. 89, 90, 122, 124, 125 (*rs*). 1879.

1880.

1. **Aitken, J.** On dust, fogs, and clouds. Nature, xxiii., pp. 195—197. 1880 (*rv*). [Read to Roy. Soc. Edin., December 20th.]
2. **Anderson, A. R.** A dry period. Symons's Meteorol. Mag., vol. xv. (No. for May), p. 57 (*rs*). [Refers to rainfall near Liverpool.]
3. **Archibald, E. D.** Nature, xxi., p. 394. 1880 (*rv*).
4. **Bicknell, P.** The dry period. Symons's Meteorol. Mag., vol. xv. (No. for July), p. 92 (*rv*). [Refers to rainfall at Beckenham.]
5. **Blanford, H. F.** Nature, xxi., p. 482. 1880 (*rv*).
6. **Burder, Geo. F.** A variety of hoar frost. Symons's Meteorol. Mag., vol. xv. (No. for March), p. 29 (*rs*).
7. **Byng, Rev. John.** A dry period. Symons's Meteorol. Mag., vol. xv. (No. for April), p. 48 (*rs*). [Refers to rainfall at Colchester.]
8. **Cantoni, G.** On the temperature and humidity of the air and the formation of dew in the neighbourhood of great lakes. Rendiconti Lombard., vol. xii. 1880.
9. **Croll, James.** Nature, xxi., pp. 521—522. 1880 (*rv*); xxii., pp. 191—192. 1880 (*rv*).
10. **Dines, G.** Symons's Meteorol. Mag., vol. xiv., p. 191 (*rs*).
11. **Fordham, H. Geo.** A dry period. Symons's Meteorol. Mag., vol. xv. (No. for May), p. 57 (*rs*). [Refers to rainfall at Royston.]
12. **Griffith-Boscawen, B. T.** Dry January. Symons's Meteorol. Mag., vol. xv. (No. for February), p. 8. [Refers to rainfall at Wrexham.]
13. **Harvey, Rev. E. W.** A travelling fog. Symons's Meteorol. Mag., vol. xv. (No. for February), p. 8 (*rs*). [Refers to a London fog at Buntingford.]
14. **King, S.** A dry period. Symons's Meteorol. Mag., vol. xv. (No. for May), p. 56 (*rs*). [Refers to rainfall at Garstang.]
15. **Ley, Rev. W. C.** Aids to the study and forecasts of the weather. 1880 (*rv*).
16. **Ley, Rev. W. C.** Nature, vol. xxii., pp. 207, 210. 1880 (*rv*).
17. **Miller, H. E.** A dry period. Symons's Meteorol. Mag., vol. xv. (No. for May), p. 57 (*rs*). [Refers to rainfall at Lowestoft.]
18. **Parfitt, Edward.** Nature, vol. xxi., p. 324 (*rv*).

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19. **Poey, A.** Comment on observe les nuages pour prévoir le temps. 3rd Ed. 1879. Noticed in Symons's Meteorol. Mag., vol. xv., pp. 2—5. 1880 (*rs*).

20. **Robie, David.** The dry period. Symons's Meteorol. Mag., vol. xv. (No. for June), p. 71 (*rs*). [Refers to rainfall at Bedford.]

21. **Smyth, C. Piazzi.** Nature, vol. xxii., pp. 194, 195 (*rv*).

22. **Tait, P. G.** Nature, vol. xxii., pp. 340, 438. 1880 (*rv*).

23. **Woeikoff, A.** Nature, vol. xxii., p. 250. 1880 (*rv*).

24. Nature. Fogs, vol. xxi., pp. 355—356. 1880 (*rv*).

25. Nature, vol. xxi., pp. 220, 363, 508. 1880 (*rv*); xxii., p. 594. 1880 (*rv*); xxiii., pp. 48, 86, 204. 1880 (*rv*).

26. Symons's Meteorol. Mag., vol. xv., pp. 2, 3, 19, 20, 40, 49—51, 160, 162. 1880 (*rs*).

1881.

1. **Aitken, John.** Dust and fogs. Nature, vol. xxiii., pp. 311—312. 1881 (*rv*).

2. **Aitken, John.** Dust, fogs, and clouds. Nature, vol. xxiii., pp. 384—385. 1881 (*rv*).

3. **Aitken, J.** Note de M. Aitken sur la formation de brouillard. Ann. Soc. Meteorol. France. 1881.

4. **Broun, J. A.** Nature, vol. xxiii., pp. 558—559 (*rv*).

5. **Capron, A. Rand.** A plea for the rainband. Symons's Meteorol. Mag., vol. xvi. (No. for December), pp. 181—190 (*rs*).

6. **Chatel.** Dust, fogs, and smoke. Nature, vol. xxiii., p. 486. 1881. [Refers to London.]

7. **Dymond, E. E.** Tables of relative humidity. Q. Journ. Meteorol. Soc., vii., pp. 1—3, January 1881. [Read to Meteor. Soc., November 17th, 1880.]

8. **Greaves, Charles.** Relative humidity. Q. Journ. Meteorol. Soc., vii., pp. 132—135 (No. for April). [Read to Meteor. Soc. February 16th.]

9. **Groneman, H. J. H.** On dust, fogs, and clouds. Nature, vol. xxiii., p. 337. 1881 (*rv*).

10. **Preece, W. H.** On dust, fogs, and clouds. Nature, vol. xxiii., pp. 336—337. 1881 (*rv*).

11. **Richter, A.** Zug der oberen Wolken n Verhältniss zur unteren Druck-und Wärmevertheilung. Zeits. f. Meteorol. Bd. xv. 1881.

12. **Russell, R.** Dust and fog. Nature, vol. xxiii., pp. 267—268. 1881 (*rv*).

13. **Whipple, G. M.** Schwackhöfer's Hygrometer. Symons's Meteorol. Mag., vol. xvi. (March), pp. 39—41 (*rs*).

14. Nature, xxiii., pp. 260, 370, 398, 427, 451, 490. 1881 (*rv*).

15. Symons's Meteorol. Mag., vol. xvi., pp. 65, 67, 68, 155, 156. 1881 (*rs*).

1882.

1. **Boerner, Prof. C. G.** The formation of dew. 1882 (*ra*).

2. **Finley, John P.** Tornadoes. 1882 (*ra*).

3. **Poey, A.** Les courants atmosphériques d'après les nuages au point de vue de la prévision du temps. 8vo. Paris. 1882. [Noticed in Symons's Meteorol. Mag., vol. xvii. (August), pp. 99—102 (*rs*).

4. **Schwedoff, T.** Symons's Meteorol. Mag., vol. xvii., p. 149 (*rs*).

5. Symons's Meteorol. Mag., vol. xvii., pp. 99, 102, 104 (*rs*).

1883.

1. **Abercromby, Hon. R.** Symons's Meteorol. Mag., vol. xviii., pp. 11, 12 (*rs*).

2. **Backhouse, T. W.** Fog gauge. Symons's Meteorol. Mag., vol. xviii. (May), pp. 58—59 (*rs*).

3. **Crosby, W. A.** Appalachia, vol. iii., pp. 132—133 (*rs*).

4. **Dieulefait, M.** Evaporation de l'eau de mer dans le sud de la France et en particulier dans le delta du Rhône. Comptes Rendus, xcvi. (Juin 18), pp. 1787—1790.

5. **Dieulefait, M.** Evaporation des eaux marines et des eaux douces dans le delta du Rhône et à Constantine. Comptes Rendus, xcvii., pp. 500—582 (Août 13).

6. **Dines, W. H.** Vapour tension. Symons's Meteorol. Mag., vol. xviii. (August), p. 107 (*rs*).

7. **Gladstone, J. H.** On fogs and fog-signals. Symons's Meteorol. Mag., vol. xviii. (March), pp. 18—21 (*rs*). [Reprint from Proc. Roy. Inst., 1863.]

8. **Lalanne.** Note on paper by Salles. Comptes Rendus, xcvii., pp. 349—350.

9. **Luröth.** On measuring the height of clouds. Symons's Meteorol. Mag., vol. xviii. (November), pp. 149—150. [Abstract of paper read to Brit. Association.]

10. **Robie, David.** Symons's Meteorol. Mag., vol. xvii., pp. 184—186 (*rs*).

11. **Salles, A.** Expériences sur l'évaporation faites à Arles pendant les années 1876 à 1882. Comptes Rendus, xcvii. (July 30), pp. 347—349.

12. **Tomlinson, Charles.** Symons's Meteorol. Mag., vol. xviii., pp. 117—118 (*rs*).

13. Symons's Meteorol. Mag., vol. xviii., pp. 17—22. Fog gauges (*rs*).

14. Symons's Meteorol. Mag., vol. xviii. (April), pp. 38—40. Scheme for the observation of the upper clouds (*rs*).

15. Symons's Meteorol. Mag., vol. xviii., pp. 18, 21, 22, 38 (*rs*).

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